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GROWER CONTROL

of the

CODLING MOTH

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OHIO AGRICULTURAL
EXPERIMENT STATION

WOOSTER, OHIO

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Grower Control of the Codling Moth
A Five Year Study of Field Practices

C. R. CUTRIGHT

INTRODUCTION

All persons experienced in apple growing have seen wide differences that exist in the control of insects in two neighboring or adjacent orchards. In one the fruit may be almost entirely free from insect injuries while in the other, injuries may be abundant. This will occur despite many of the same practices which may have been used in both plantings.

For many years, numerous occurrences of this type have been noted in the fruit growing area of Ottawa County, Ohio. It has been especially true of codling moth damage. As early as 1924, when a fruit growers' tour was conducted in this area, several orchards visited showed different rates of infestation by the codling moth, and the question was raised as to why such a condition existed. Apparently all the growers had used about the same spray schedules but for some reason the results were quite diverse.

At this time, injury by the codling moth was one of the chief factors detrimental to profitable apple production throughout Ohio. Consequently, it appeared necessary to investigate all phases of codling moth activity and especially those that might have a bearing on differences in control such as were being noted in this area. A project outlining possible factors to be considered was prepared, and approved, and work was started in 1944. The total period of the investigation included the years 1944 to 1948, inclusive.

LOCATION

As already indicated, this study was made in the fruit growing area of Ottawa county. This includes the seven eastern townships of Danbury, Catawba Island, Portage, Bay, Erie, Carrol and Salem. Catawba Island and Danbury townships, particularly, have a long record of commercial fruit production which started before the Civil War. Grapes were the first fruit most widely grown, followed by peaches. Apples have become increasingly important since 1910. At the present time (1949) there is some recession in apple planting. Table 1 shows the general trend in apple production for Ottawa County.

Table 1. Apple Production in Ottawa County
1909 - 1944, inclusive
Official U. S. Census Figures.

Year	Bushels
1909	41,609
1924	105,596
1929	72,896
1939	303,598
1944	187,024

Ottawa county was chosen as the location for this experimental project because of a number of factors including the following:

1. This fruit growing area is one of the more important horticultural centers of the state.
2. Great variability in codling moth damage which could not be satisfactorily explained existed in different orchards.
3. Horticultural practices seemed quite uniform in the area.
4. The same varieties of apples could be found in almost every orchard.
5. Climatic conditions are essentially uniform for the area. All orchards are located on level land within a few miles of Lake Erie. There is probably not more than 10 feet difference in elevation between the orchards in the area. These conditions eliminated climatic differences as possible reasons for variability in codling moth damage.

Due to these many uniform conditions the area offered unusual advantages for a study of grower controlled factors which affected codling moth control.

METHODS OF STUDY

The first steps in making this study were to inspect aerial photographs of the area and to map all apple orchards. This gave valuable information as to density of planting, size of orchards and trees, and their general location. The next step was the selection of specific orchards, each of which was to undergo special study.

Originally two representative orchards were selected from each of the seven townships although later several others were included. Data on all known and suspected factors that might influence codling moth infestation were secured from each orchard. These included acreage, age of trees, varieties, acreage and age of adjacent orchards, type of pruning, thinning if practiced, type of buildings in or adjacent to the orchard, crop handling, inter-planting with other fruits, sanitary practices and spray equipment. Changes in any of the above from year to year were noted.

Each season a record of the spray schedule in each orchard was taken. This included type and amount of materials used, time of application and amounts of dilute spray. Observations on the method of spray application and coverage were made in each orchard.

Visits were made to every orchard at approximately two-week intervals starting when the first codling moth entries were expected. At each visit a count of injuries was made so that the course and amount of damage was known for each date. Visits stopped shortly before the anticipated date of McIntosh harvest. This general plan was used each season for the five-year study.

From the large amount of data collected in this manner, two different studies were made.

First, a study was made of factors affecting the area as a whole and over which the individual grower has little control. This included (1) an investigation of climatic conditions characteristic of this area and variations in climate occuring from year to year, (2) the life cycle of the codling moth in the area, (3) seasonal crop yields, (4) density and age of apple plantings, and (5) degree of resistance by the codling moth to lead arsenate in the different orchards.

Second, a study was made of factors over which the individual grower has a degree of control. This was made with special reference to the individual orchard units studied. The data obtained are presented in tabular form for the five years of the study and show the seasonal operations, spray schedules and the development of codling moth infestation, together with a statement regarding the salient findings for each individual orchard.

PRACTICES AND FACTORS AFFECTING THE AREA

Size of orchard and density of orchard plantings. Individual growers can select a site for an orchard and can also control its size, but once the orchard is planted the site is fixed and the orchard is subject to many influences that arise due to the activities on adjacent land. For example, a profitable orchard may inspire an adjacent planting. The final result is an area densely planted to orchards in which one grower is almost helpless unless he chooses the drastic course of cutting out or abandoning his orchard.

Numerous entomologists and plant pathologists have noted the difficulty of producing a product free from insect and disease damage in areas devoted almost entirely to the production of one fruit. Conditions in such an area definitely favor the insect or other pests. Abundant food is at hand; if there is a short crop there are always a few fruits on which the insects can concentrate and feed. Facilities for migration are at their best when other plantings are adjacent or nearby.

The data collected in Ottawa county show that as a general rule, the codling moth is most difficult to control in areas where apple orchards are large or numerous and planted close together. Such a condition exists in Bay Township where a considerable portion of the land is used for apple growing as shown in figure 1. Orchards in this township although carefully sprayed have had great difficulty in controlling codling moth, particularly before the introduction of DDT.

On the other hand where orchards are isolated or at least have some distance between them, the codling moth will not be so severe if other factors are equal. This condition exists in Salem Township where the control is not a special problem. (Figure 2).

Age of trees. After an orchard has been planted the grower has little control over the age of his trees. His actions are restricted and he must live with his trees despite their age. In the Ottawa county orchards studied only two had half the trees over 30 years of age. Most of the others were approaching maturity, but still were less than 25 years of age in 1944 and only one block was less than 10 years old.

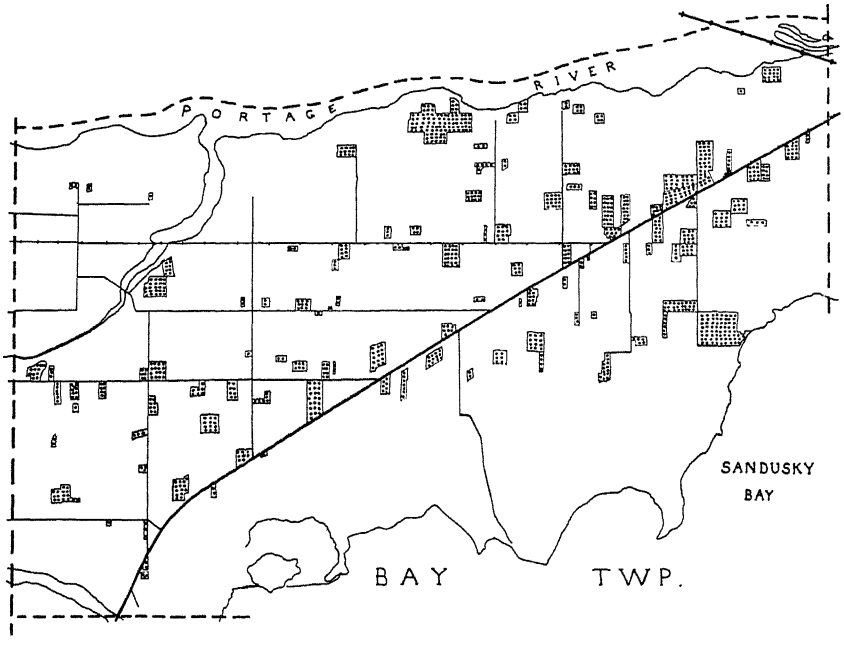

Figure 1 — Map showing the numerous, large orchards in Bay Township, Ottawa County. Where orchards are large, numerous and adjacent, more difficulties in codling moth control may be expected.

In general, the control of insects is more difficult on mature trees. This is shown by an inspection of the data in the Appendix, obtained from orchards numbers 5, 6, 8, 11, and 13, all of which contain some mature trees. However, an exception is provided by orchard number 15 where, despite the maturity of the trees, excellent control of insects has been secured. Use of an effective insecticide has greatly improved conditions in orchards number 8 and 13.

Codling moth resistance to lead arsenate. The fact that the codling moth tends to develop a resistance to the action of lead arsenate is well known to entomologists.[1] This condition is brought about by the continual exposure of the insect to this poison.

Early in this study differences were noted in the infestation of various orchards that could be attributed only to their resistance to lead arsenate. As the study progressed, condition in different orchards clearly indicated different degrees of resistance existing among the various codling moth populations. Time and the lack of technical assistance did not permit the development of positive proof of such conditions. It is felt, however, that if

[1]Hough, 1928-34-43.

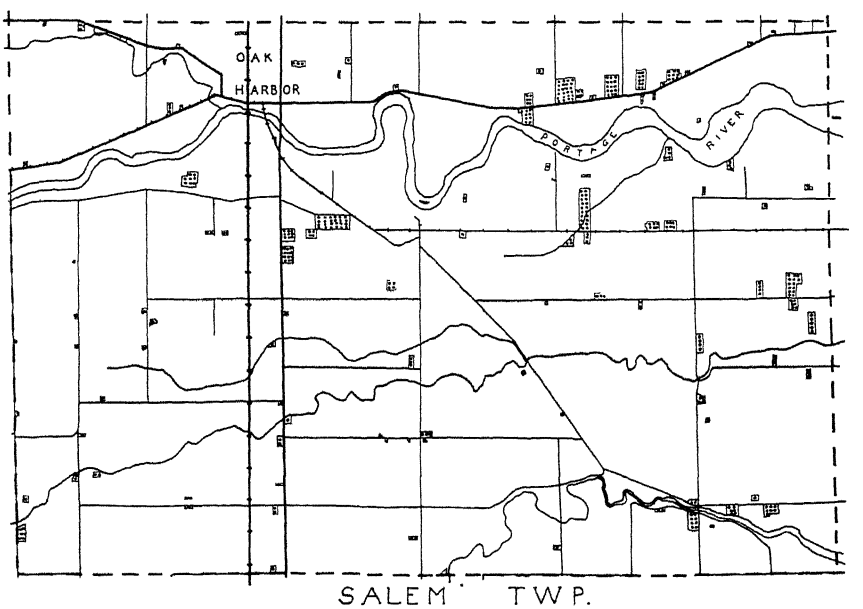

Figure 2 — Apple orchards in Salem Township. Note the small orchards most of which are widely separated. Codling moth control in this township has not been a difficult matter.

larvae from the different orchards could have been reared in laboratory experiments designed to prove such differences, the field observations could have been definitely confirmed.

Table 2 indicates varying degrees of resistance to lead arsenate found in different orchards. These were determined by studies of rate and degree of codling moth infestation and of the spray schedule including number of spray applications of both lead arsenate and DDT, gallonage per tree-year and timing. It is felt that this is a fairly accurate summarization of the status of resistance to lead arsenate in the orchards.

Table 2. Codling moth resistance to lead arsenate in the different orchards.

Orchard No.	Status of resistance
1	Slight resistance, not serious
2	Very resistant, serious
3	Some resistance
4	Rather serious resistance
5	Very resistant, serious
6	Some resistance
7	Medium resistance
8	Resistant, serious
9	Slightly resistant
10	Some resistance
11	Medium resistance
12	Very resistant, serious
13	Very resistant, serious
14	Slightly risistant
15	Little or no resistance

It is thought that orchards number 1, 3, 6, 9, 10, 11, 14, and 15 could continue to raise crops fairly free of codling moth if lead arsenate were used. This pre-supposes that spray applications would be thorough and timely and that near normal sized crops were being produced. In years of very light crops, orchards number 3, 6, 10, and 11 would probably have difficulty. On the other hand orchards number 2, 4, 5, 7, 8, 12, and 13 should not rely on lead arsenate to control the codling moth. This was strikingly demonstrated in the early summer of 1948 when orchards 10 and 8 went back to lead arsenate after using DDT for two years. In both orchards the appearance of numerous stung and wormy fruits, before July first, caused the growers to abandon lead arsenate and return to the use of DDT.

Orchards sprayed most heavily and most frequently in the past seem to be those in which most resistance is present. However, this is not always true as is shown by the case of orchard 15. This orchard has been thoroughly

sprayed with lead arsenate for years but no codling moth problems has developed. This orchard is not large and the codling moth populations have been kept so low from year to year that resistance has not appeared. A fairly large population of codling moths in any orchard seems to be the first condition necessary for the development of resistance.

Since the codling moth has developed resistance to lead arsenate it can be expected that a similar resistance to other spray chemicals, such as DDT, may develop at some future date. This being the case new and effective spray materials should constantly be in the process of development, or methods of using other factors detrimental to the insect should be found.

Orchard yields as affecting codling moth infestation. Insect injuries to apple fruits are always more abundant in seasons when the crop is short. However, the seriousness of such situations was not fully appreciated until data obtained in this study were compiled. Crop status in terms of percent of a normal full crop for each orchard during the period of this study is given in Table 3. The crop of 1943, the year preceding the start of this work, was very light, corresponding quite closely to that of 1945.

Table 3 shows the wide variability in the size of the crop for the different orchards in the different years. The seasonal means also show the great differences that occur from year to year for the group as a whole.

Table 3. Apple crops in Ottawa County orchards 1944-1948, inclusive. In terms of percent of a normal full crop.

Orchard No.	1944	1945	1946	1947	1948	1949
1	75	5	50	45	35	90
2	—	8	60	20	10	30
3	15	8	20	25	20	70
4	65	25	75	35	35	85
5	30	10	30	35	10	70
6	25	15	18	20	5	80
7	60	15	35	40	25	75
8	40	30	45	40	20	80
9	60	20	60	30	35	90
10	70	10	20	50	30	90
11	40	8	50	20	20	65
12	30	10	10	25	30	75
13	40	35	45	65	20	75
14	70	8	15	45	30	85
15	40	15	15	20	25	80
Seasonal Means	47.1	14.8	36.5	34.3	23.3	75.3

When these seasonal means are correlated with the percent of fruit free from codling moth damage, a marked degree of correlation results as shown in figures 3 and 3a. Figure 3 is slightly distorted due to the fact that DDT became the dominant insecticide in 1946. However, despite this variation, the increase in percent of clean fruit as the crop size increases is very marked.

Records of individual orchards show the effect of crop size on infestation. In 1945, for example, 14 out of the 15 orchards showed an increase in codling moth damage. In the one orchard (No. 8) where better control was obtained, the crop was not greatly decreased from that of 1944. Much the same condition occurred in 1948 in the orchards where a crop decrease was experienced.

There are two reasons for the increase of injury during years of a short crop. (1) The codling moth concentrates on the few remaining fruits producing a much higher percentage of injured apples. (2) The grower unknowingly or otherwise will use poorer spray practices and less spray material providing mediocre protection for the fruit present. Trees with a light crop will receive less spray and there is a tendency to "skip" trees showing only a few fruits.

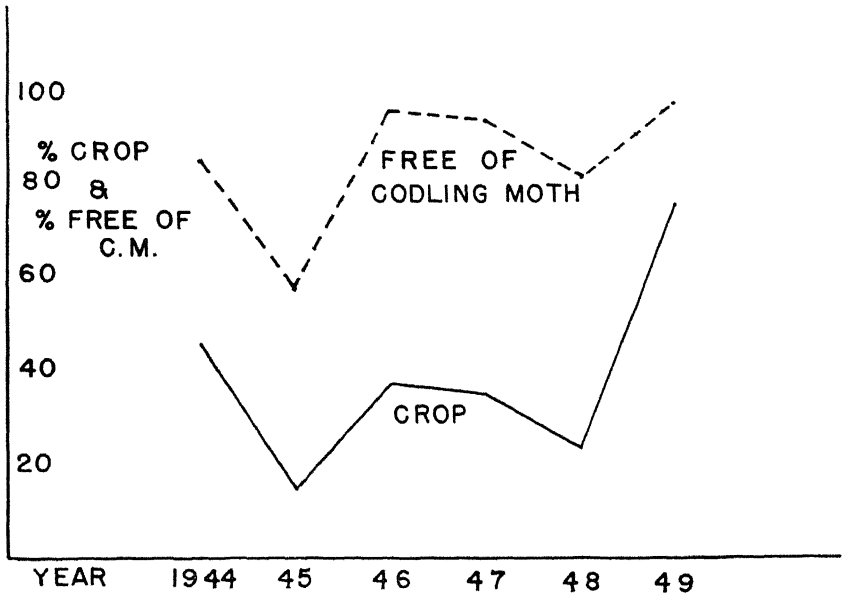

Figure 3 — Correlation between the amount of crop and percent of the crop free from codling moth damage. Otawa County, 1944-1949, inclusive.

Growers must learn to recognize the possibilities of greatly increased damage in seasons producing a short crop and be prepared to combat this tendency by more and better spraying.

Climatic factors. Influence of weather on the life cycle and the amount of damage the insects can do has been recognized by entomologists for many years. In this field, the codling moth has received much attention. Notable work has been done by Glenn (1) who determined the heat units necessary for the development of codling larvae and pupae. Shelford (2) studied the effect of moisture and light in relation to the effects of temperature. Isely and Ackerman (3) worked on the effect of evening temperatures on egg laying by the codling moth. They showed that no eggs are laid at temperatures below 63°F. and very few at 65°. From 65° on, oviposition increases until it reaches a maximum at 85°F. In 1936, Isely and Schwardt (4) and Cutright (5) working independently, showed that most sever infestations of codling moth follow periods of high temperatures during late May and throughout June. Findings from studies such as these have greatly influenced the timing and arrangement of recommended spray schedules.

From Table 4 it can be seen that temperatures have been below normal in the Ottawa county area except in 1944. In this year the high temperatures in May and June were favorable to the codling moth and many damaged fruits resulted. However, the crop, being above average, made the loss less prominent than in other seasons. Temperatures during the growing seasons

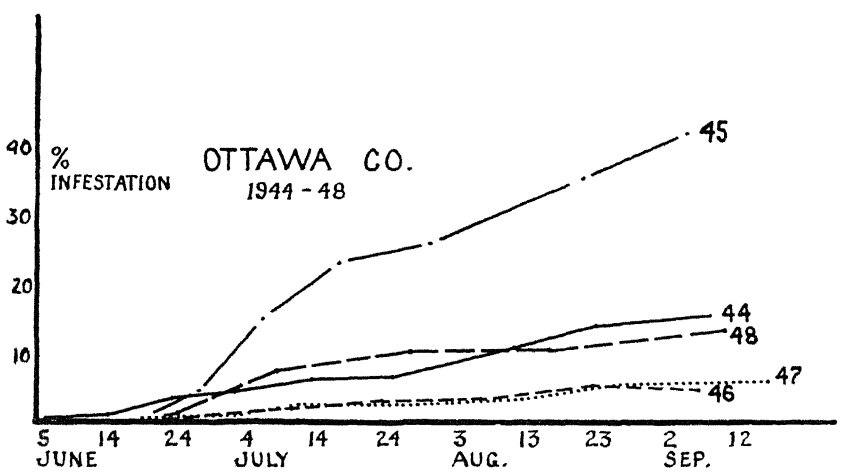

Figure 3A — Mean seasonal codling moth infestation for Ottawa County as a whole, 1944-1948, inclusive. In 1944 and 1945 lead arsenate was the insecticide. DDT was used in the other years. 1945 and 1948 were years of very light crops.

Table 4. Temperatures at the Catawba Island Weather Bureau Station during the growing seasons of 1944 to 1948, inclusive, expressed in terms of plus or minus degree F. departure from the mean.

Month	Mean temperature	1944	1945	1946	1947	1948
May	59.4	+3.8	−6.0	−1.9	−3.0	−2.3
June	69.8	+2.5	−4.0	−1.4	−3.6	−1.7
July	74.9	−0.3	−4.1	−1.9	−4.2	−0.9
August	74.4	+0.7	−1.0	−5.0	+3.5	−1.0
September	66.7	−1.1	+0.9	− 0.5	−0.4	−0.1

of 1945, 1946, 1947, and 1948 have, with the exception of a few months, all been unfavorable to the codling moth. Low temperatures during May and June were marked, particularly in 1945. However, the unfavorable factors during a short crop year permitted a very high percent of infested fruit. The same factors also operated in 1948.

In practically all seasons, periods of hot weather occur during which the codling moth does much damage. Such weather may last for only a week or 10 days but, if it comes at a strategic time, damage may result. Three such periods were noted during this study. One came in late June of 1945, just after most moths of the spring brood had emerged. This permitted laying large numbers of eggs, which hatched later and resulted in much damage. Temperatures in 1948 were below normal. However, two warm weather periods occurred, the first at the same time as the one of 1945, and the second after mid August. This later period permitted more egg laying and better establishment of young larvae. It caused increased late season damage during that year.

Since it is known that high temperatures favor the codling moth, it is advisable to keep fruit covered with spray during warm periods and also to make spray applications more frequently.

Although temperature is by far the most important climatic factor affecting codling moth injury, rain, wind, and sunshine also play some part. Moisture is necessary for the normal emergence of moths. Increased emergence will be noted following rains, particularly if the rain was preceded by a dry period. Moths are restricted in flight by strong winds but will fly freely in a light breeze. Light also affects the moths, as can be seen by their evening flights and by movements toward certain sources of light and light intensities. Most eggs seem to be laid around the outside of the tree and a higher percent of injured fruit is found in this area.

As yet there are no known methods of utilizing information on moisture, wind, and light in the practical control of codling moth.

Life history of the codling moth, Ottawa County. Because it was impossible to have an investigator on continuous duty in Ottawa county, biological notes are not as complete as could be desired. However, enough data was collected so that a fairly accurate picture can be drawn. In each season, notes were taken on larvae leaving apples and on emergence of spring and mid-summer brood moths. Data on larvae leaving fruits were obtained by collecting larvae from bands placed on the trunks of bearing apple trees. Such collections were made as frequently as possible and were taken during each of the five seasons. These data in terms of percent of the total number collected per season are shown in Figure 4.

Data in Figure 4 are influenced by many different factors. For example, in 1944, all larvae were collected from sprayed trees. This record was abruptly terminated by the harvesting of the fruit in late September. The record of 1946 was taken from unsprayed trees and as no harvest occurred, the data cover a longer period of time and show the high percent of larvae leaving fruit in late season. Unsprayed treees were also used in 1947 but large numbers of late season larvae were removed from th bands by woodpeckers, greatly reducing the percent of larvae captured. The same conditions

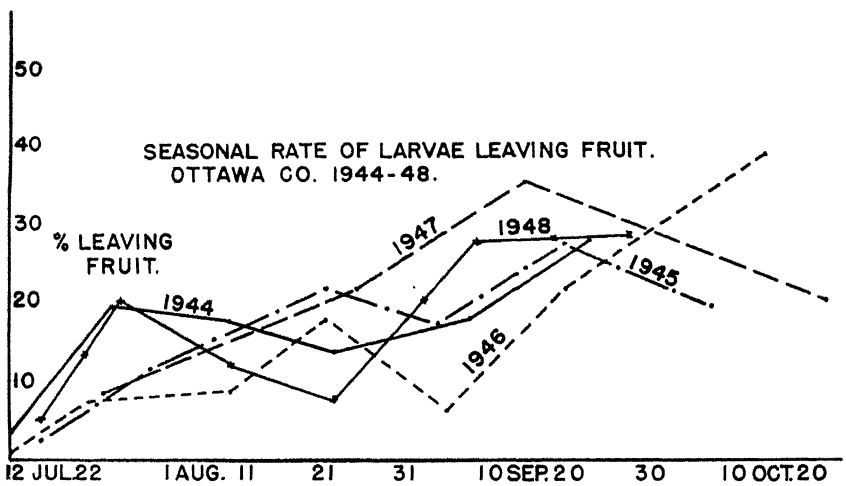

Figure 4 — Seasonal rate of codling moth larvae leaving apples during the five years' study in Ottawa County, 1944-1945. Note that in all seasons larvae are continuously leaving the fruits from early July until October. The percent figure means the percent of the total number of larvae for the season that were collected on the different dates.

existed in 1948 except that attacks by woodpeckers were much less severe They did influence the data and caused an earlier trmination of the record.

A review of all data indicates that larvae from the midsummer generation of moths first appear about August 30. Seasonal conditions may cause either earlier or later dates of first appearance. Although moths of the first generation are always more numerous than those of the mid-summer brood more larvae are produced by this later group shown in Figure 4.

Records of emergence of moths of the mid-summer brood were obtained in all five seasons. In all cases numbers of moths from first generation larvae were smaller than expected. Data on this point are given in Table 5.

Table 5. Percent of first generation larvae that emerge as moths during the same season.

Year	Number of first brood larvae	Number of mid-summer moths	% of mid summer moths
1944	340	44	12.9
1945	492	40	8.2
1946	915	111	12.0
1947	114	25	21.8
1948	132	46	34.8

Data taken at Wooster, Ohio, over a long period of years indicate that between 40 and 50 percent of first brood larvae transform per season. This is much higher than in the Ottawa county area.

Despite the lower percentage of mid-summer brood moths that occur in Ottawa county their progeny cause more proportionate damage than occurs at Wooster. This is thought to be due to higher mean temperatures. (Catawba Island—August 74.4, September 66.7°, Wooster—August 69.7, September 63.9°).

Graphs showing emergence periods of mid-summer moths are given in Figure 5. Earliest start of emergence was July 18, 1944. Usually, few moths appear in July. The peak usually falls between August 12 and 17 and the number of moths declines rapidly after this time. The five-year record of mid-summer emergence indicates that a somewhat later date for the mid-summer spray should be recommended. This was done in 1947 and 1948 with very good results. Formerly, recommended dates for this spray averaged from July 25-31, while the new dates have fallen as late as August 5.

Records on spring brood moth emergence were secured from 1945 to 1948, inclusive and were taken at two points in the area. Cages were located near Oak Harbor, about five miles from Lake Erie and on Catawba Island,

about one-half mile from the lake. These records are shown in Figures 6 and 7.

Emergence has always started earlier at Oak Harbor than on Catawba Island. Peak emergence is also earlier although not as marked as is the case with first appearance. On Catawba Island moths appear later and emergence usually covers a longer period. Weather conditions, particularly temperature, greatly influence all these activities.

Dates of first injuries on fruits are shown on graphs depicting development of seasonal infestation for the area and for individual orchards. A summary of these data in relation to the appearance of the first moth and to the peak of spring brood emergence is given in Table 6.

All seasons were cool. In a warm year such as 1944, injuries on fruits were seen as early as June 3.

The wide variation in the length of time between appearance of the first moth and peak emergence to the date of first noticeable injuries on

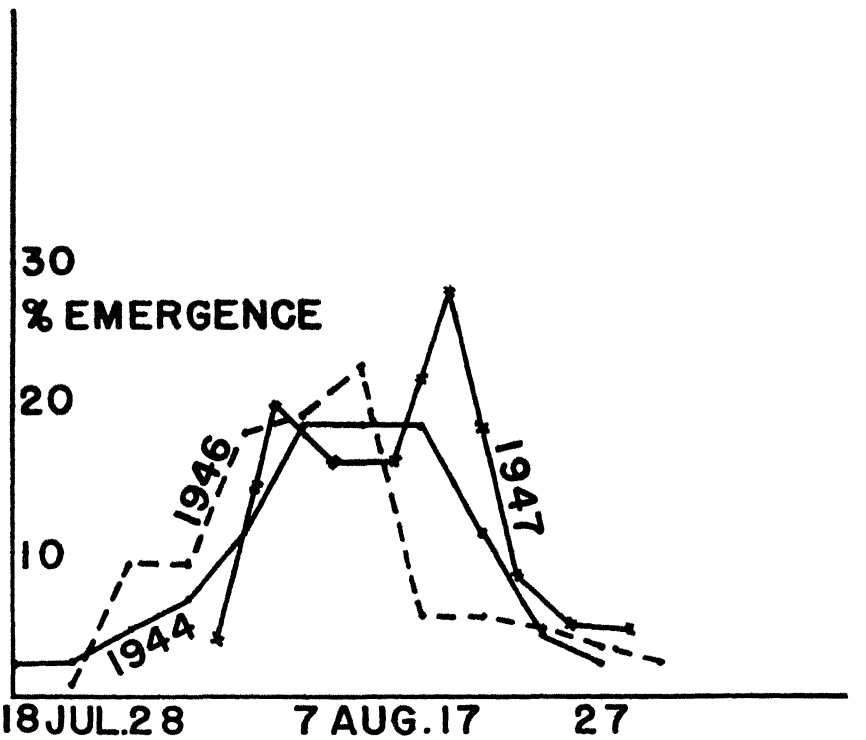

Figure 5 — Emergence of mid-summer brood moths occurring in Ottawa County in 1944, 1946 and 1947. After a peak is reached, there is usually a rapid decline in the number of moths.

Table 6. Ottawa County date of first observed inuries on Fruits in relation to time of First moth emergence, and peak emergence.

Date of emergence			First injuries on fruits		
				Days after	Days after
....Year	1st moth	Peak	Date	1st moth	Peak
1945	May 11	May 27	June 18	38 Days	22 Days
1946	May 15	May 31	June 10	26 Days	10 Days
1947	May 28	June 7	June 17	20 Days	10 Days
1948	May 17	May 29	June 18	32 Days	19 Days

fruits is due to climatic differences. In individual orchards a timely, well-applied spray of effective materials will cause even great differences. Moth emergence is not an accurate guide to the time of appearance of first injuries.

The influence of the life history on spray practice. A study of the life history data and of the different spray schedules in the Ottawa county area leads to several definite conclusions. First brood injuries in considerable

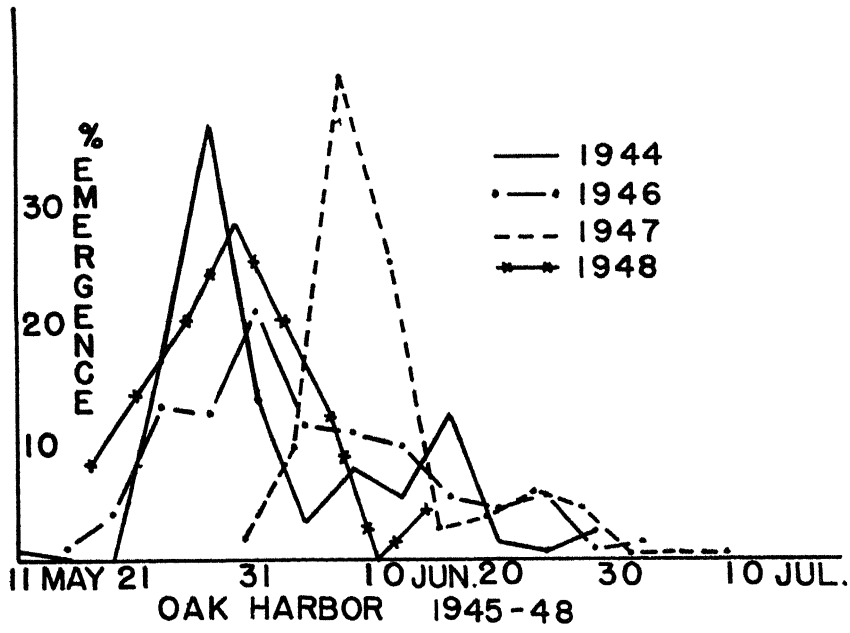

Figure 6 — Emergence of spring brood moths in Ottawa County, as occurring at Oak Harbor. First emergence and peak emergence averaged several days earlier than on Catawba Island.

numbers appear over a period of at least five weeks. This means adequate spray protection should cover that period. Since two week's protection is about the maximum covered by one spray, even with DDT, three spray applications are necessary to protect the crop. In the spray schedule these sprays are usually designated as the second, third, and fourth covers. The fourth cover will usually be applied from July 2 to July 10. This spray should provide protection during the remainder of first brood attack. During the last two weeks in July and usually during the first few days in August there are few young larvae. Therefore, sprays applied during this period do not give full value for cost and labor required.

In many sections of Ohio, and even in some orchards in Ottawa county, one second brood spray will give good control of codling moth for the balance of the season. Due to the severity of second brood attack in Ottawa county two sprays are usually necessary. This condition was shown in 1948 when eight operators applied only one early August spray against second brood. In their orchards the percent of injured fruits increased 7.1 percent from mid-August to mid-September. Seven other orchardists applied two sprays, one in early August and the other about 15 days later. In these orchards codling moth injuries did not increase. Counts showed an average decline of .2 percent for orchards receiving two sprays.

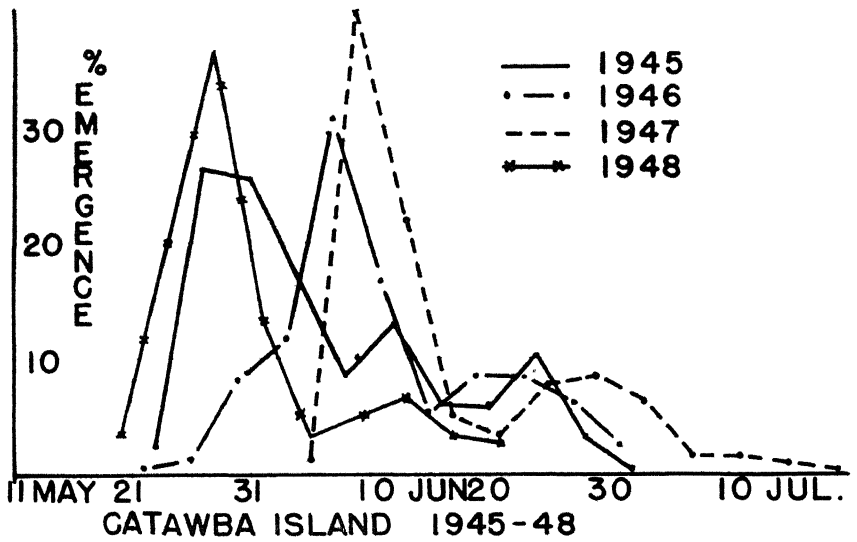

Figure 7 — Spring brood codling moth emergence as occurring on Catawba Island, Ottawa County. Late emergence is the rule in this area.

STUDIES OF INDIVIDUAL ORCHARDS

Information concerning individual orchards has been arranged in tabular form and is presented in the Appendix. In the text which follows immediately, the salient points encountered in each individual orchard are summarized. Reader are referred to the Appendix for tabular data.

Orchard No. 1

Data from orchard number 1 for the five-year period of this study are summarized in Tables 7, 8, 9, as shown in the Appendix and in Figure 8. A close study of these data will indicate several factors influencing control as shown in Figure 8. One was the heavy infestation in 1945. This was due to a short crop, resulting in a shortened and poorly applied spray schedule. Since the weather of 1945 was unfavorable to the codling moth, the poor control obtained shows clearly what a poor crop, together with poor spraying, can do even in a good orchard. Good spraying and a larger crop in 1946 showed good control.

In 1947, DDT made its first appearance in the spray schedule when it was used against second brood with good results. DDT was also used in late

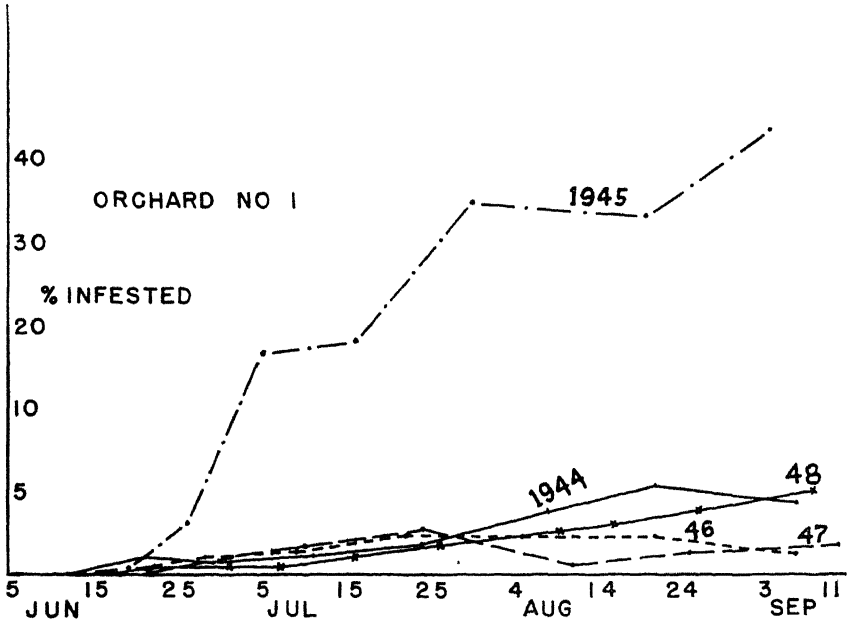

Figure 8 — Seasonal development of codling moth infestation in orchard 1, 1944-1948, inclusive. The contrast between the heavy infestation of 1945 and the conditions in other years is very marked.

applications in 1948 but dust formulations were applied instead of liquid. It is felt that this change was responsible for the increase in codling moth damage experienced in 1948. Generally good control with lead arsenate marks this orchard as one in which codling moth has not developed particular resistance to this insecticide. No adjacent apple orchards and no nearby buildings have also helped. In this planting the variety Cortland has always been most heavily infested.

Orchard No. 2

Orchard No. 2 consists of several large blocks, which collectively make up one of the larger apple orchards of this area. Peaches, cherries, and plums are also grown.

Figure 9 shows the seasonal codling moth record for the four years this orchard was studied. Again the great difference in control in 1946-1947 as compared with 1945 is clearly seen.

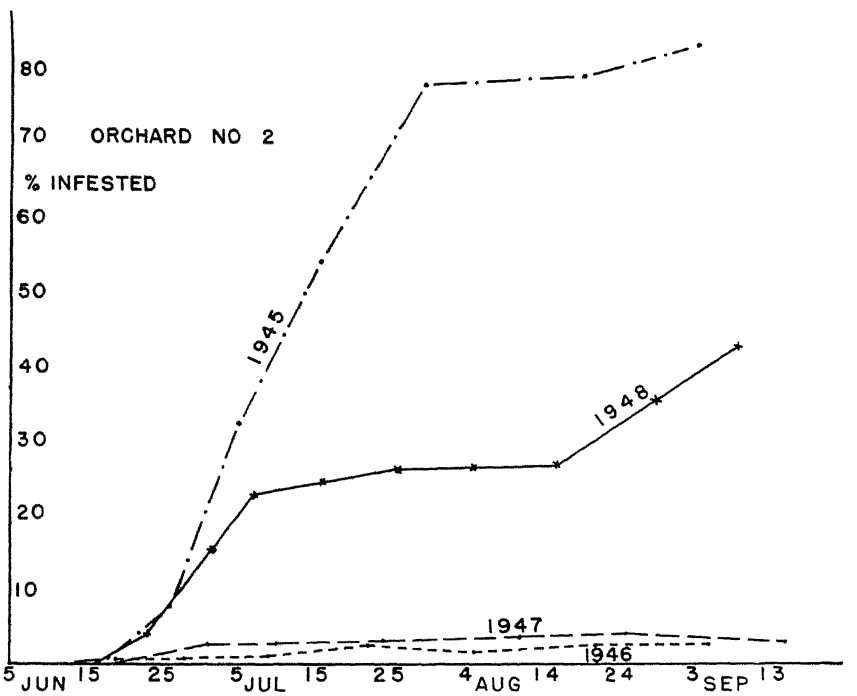

Figure 9 — Seasonal development of codling moth infestation in orchard 2. 1945-1948, inclusive.

The 1945 spray schedule consisted of 11 cover sprays of lead arsenate at the rate of 4 pounds per 100 gallons of water. In 1946, one cover spray of lead arsenate plus six of DDT were used and in 1947 one lead cover and four of DDT. Codling moth in this orchard appear definitely resistant to lead arsenate. Poor control in 1948 is due to several factors. First, there was a poor crop which resulted in poor spraying with no material applied to many trees with light crops. Second, in early spring the owner underwent a serious surgical operation and for several months was not able to work or supervise operations. Third, a trusted employer was killed in an accident which upset plans and work. Fourth, the spray schedule was three covers of lead arsenate and three of DDT. Possibly fewer DDT sprays permitted some increased damage. All of these factors played a part in the poor control picture, but it is considered that the most important was that of a poor crop.

Orchard No. 3

Orchard number 3 is distinct in that a severe system of pruning has been used to keep the trees low. Trees are little more than half the size normally

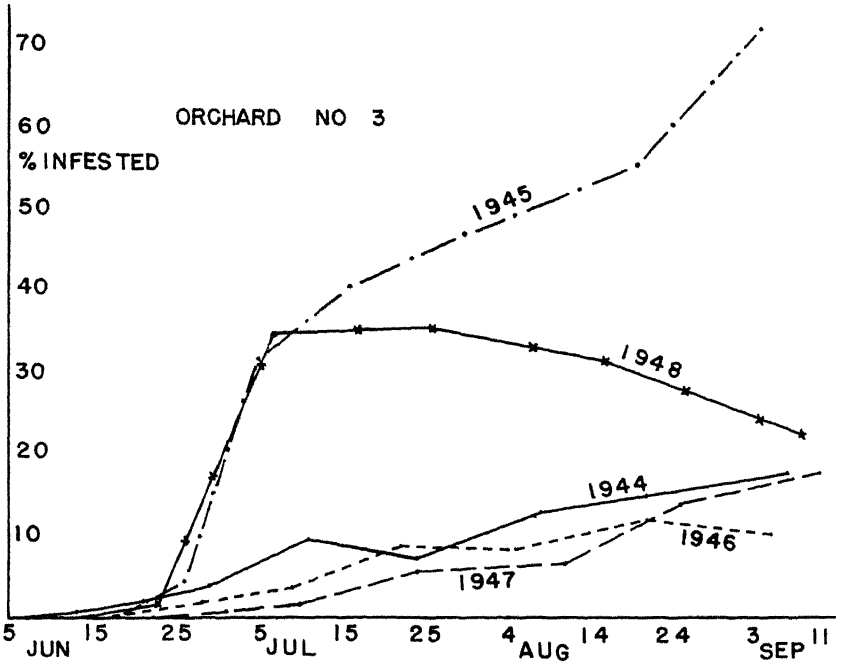

Figure 10 — Seasonal development of codling moth infestation in orchard 3. 1944-1948. Note the decline in the infestation in late 1948 due to the introduction of throught DDT sprays starting in early July. The dropping of early infesed fruits and lack of new injuries caused this decline.

expected. Varieties grown included a high percentage of Red Delicious and Stayman Winesap which created a pollinization problem resulting in low production and consequent difficulty in codling moth control. Data regarding other factors are given in the tables. At the start of this study, spray equipment was not adequate for this orchard and this together with poor crops resulted in poor codling moth control. Since the addition of DDT to the spray schedule did not entirely correct this condition indicates that these were the actual factors. The block being adjacent to two small uncared for orchards added to control difficulties.

Orchard No. 4

Trees in this orchard are not opened up as much as could be desired for good spraying. The codling moth was fairly resistant to lead arsenate and prior to the introduction of DDT in 1946 they were hard to control. However, good spraying with DDT has been effective despite the handicap of thick trees. Location of the orchard adjacent to an abandoned planting of apples illustrates the effectiveness of a thoroughly applied DDT schedule. In 1947, dusting was compared to spraying in this orchard. A 5 percent DDT dust was used but codling moth was not as well controlled as where DDT in a liquid was applied.

Many varieties of applies are grown in fairly equal numbers. These are also well distributed throughout the planting. This has created excellent

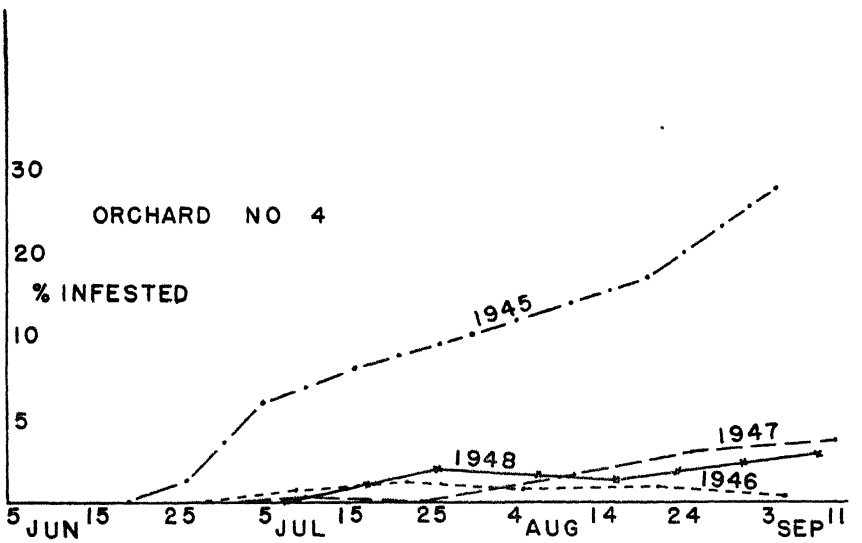

Figure 11 — Seasonal infestation of codling moth in orchard 4. Note the good control that was obtaained as soon as DDT was included in the spray schedule.

conditions for pollination and the production record is good. Good crops are always an aid in codling moth control.

Orchard No. 5

This orchard is primarily mature despite the presence of several rows of young trees. Records prior to 1944 as well as data taken in that year and in 1945 indicate that the codling moths in this orchard had developed considerable resistance to lead arsenate. Amount of spray used in the orchard is below normal. Fruit production has been low, especially in 1945 and 1948. These factors have all played a part in generally poor control of codling moth.

Orchard No. 6

Although numerous varieties are grown, reducing the pollinization problem, this orchard has produced poorly. This was especially true in 1945 and 1948. Codling moth has been difficult to control in those years even though there is little evidence of resistance to lead arsenate or other chemicals. Gallonage of spray used has been below normal and is probably a factor in poor control.

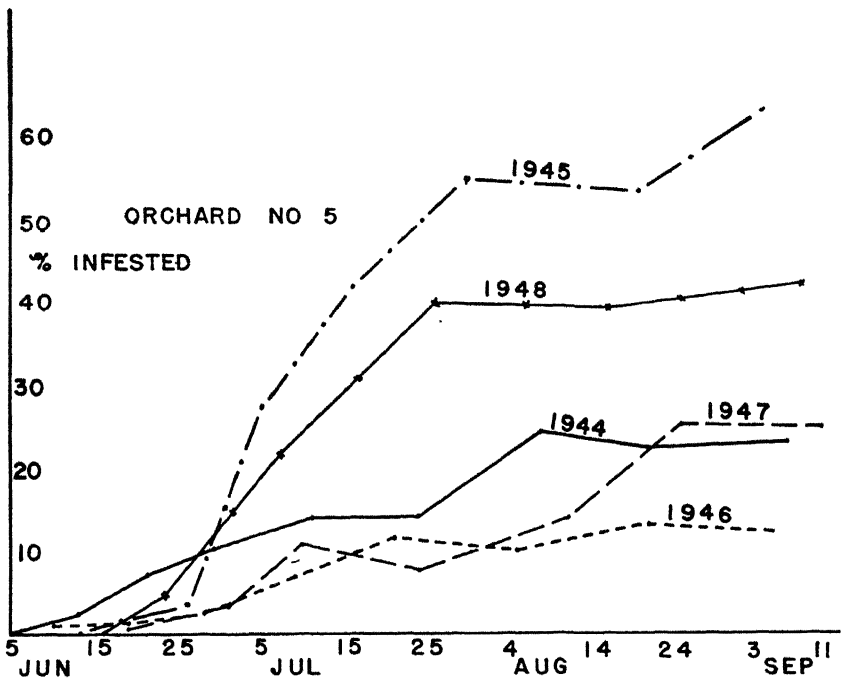

Figure 12 — Seasonal codling moth infestation. Orchard 5. Note poor control especially in poor crop years of 1945 and 1948.

Orchard No. 7

This is a large, well-grown, well cared for, and well-equipped orchard. It has not been especially productive due to a large number of Red Delicious trees. In years of light crops, codling moth has been rather difficult to control even though sprays were applied thoroughly. In 1944, control was definitely aided by hand thinning. A considerable resistance to lead arsenate had been developed by codling moth. From this, it is evident that more than good equipment and good coverage is needed for best control of this pest. Use of DDT has greatly improved this situation.

Orchard No. 8

This is a large, well-established orchard, producing peaches, plums, and pears as well as apples. Business aspects of fruit growing are emphasized. Good equipment is available and is used. Good spray practices had been used for years but codling moth had developed a definite resistance to lead arsenate and consequently poor control had been experienced for several seasons. Use of DDT starting in 1946 corrected this condition and good control was secured in 1946, 1947, and 1948. An effective insecticide was the factor needed for control.

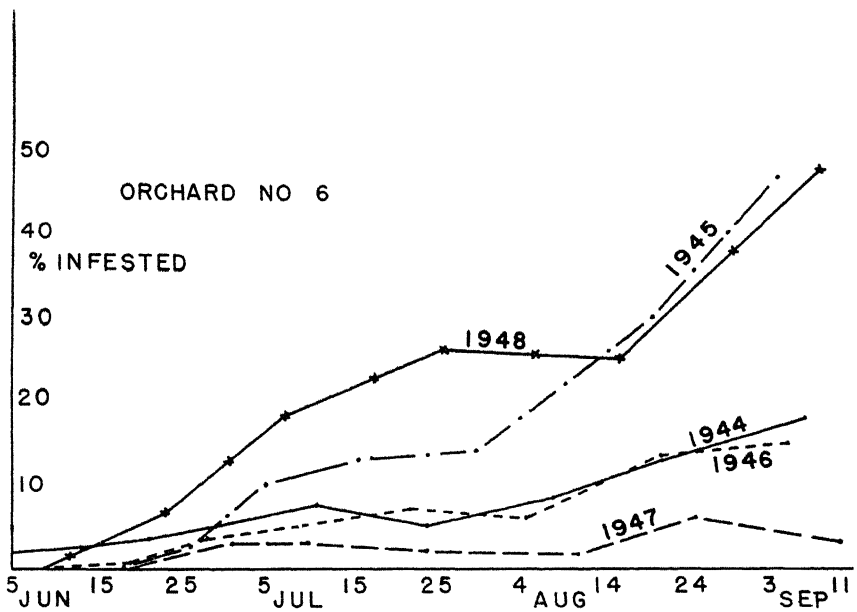

Figure 13 — Seasonal infestation by codling moth. Orchard 6, 1944-1948, inclusive. Note poor control in 1945 and 1948.

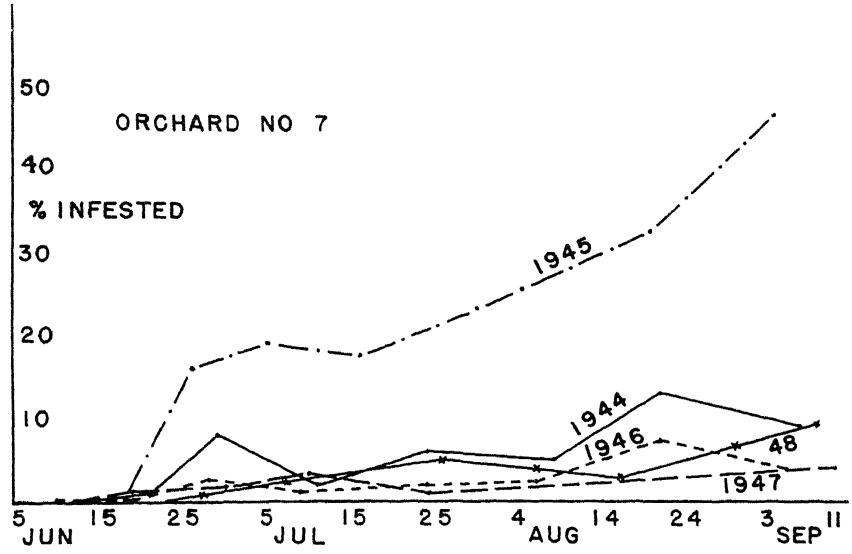

Figure 14 — Seasonal infestation by codling moth in orchard 7. Note drop in infestation during July and August 1944, due to hand thinning of infested fruits. Despite a heavy spray schedule serious injury was suffered in 1945 due to a short crop.

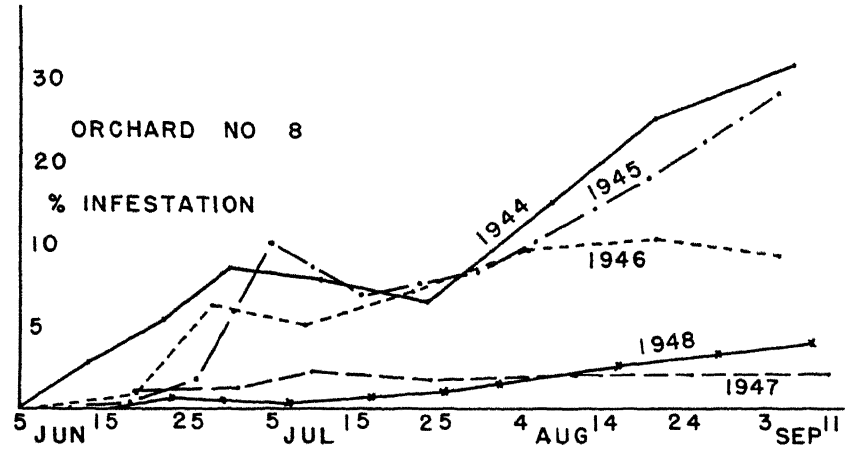

Figure 15 — Seasonal codling moth infestation in orchard 8. Note the improvement in control as soon as DDT was used in this orchard.

Orchard No. 9

This is one of the smaller orchards included. The owner also grows other fruits and is interested in grain, forage, and some vegetables. Despite this range of interests, good apples are produced and codling moth control has been effective. Codling moth has not developed much resistance to lead arsenate and populations have always been kept within bounds. Thinning has been practiced on heavily loaded trees and has definitely helped. A complete spray schedule has been thoroughly and effectively applied each year regardless of the size of the crop. The orchard is semi-isolated and is not old. All of these factors seem to have aided in control.

Orchard No. 10

During this study, good control has been secured in this orchard. Spraying has been consistent, timely and thorough. Codling moth had acquired some resistance to lead arsenate. This was quite noticeable in the short crop year of 1945, and also in June and July of 1948, when a light crop was sprayed with lead arsenate during the period of first brood activity. A change of DDT corrected this condition in the latter part of the season. DDT was used entirely in 1946 and 1947 and excellent results were obtained. Good planning and an efficient work crew has also been of great importance in control of codling moth and other pests.

Orchard No. 11

An irregular spray program has produced rather poor results in this orchard. The owner is a general farmer and is fequently busy with other work when spraying should be done. In poor crop years there was a tendency

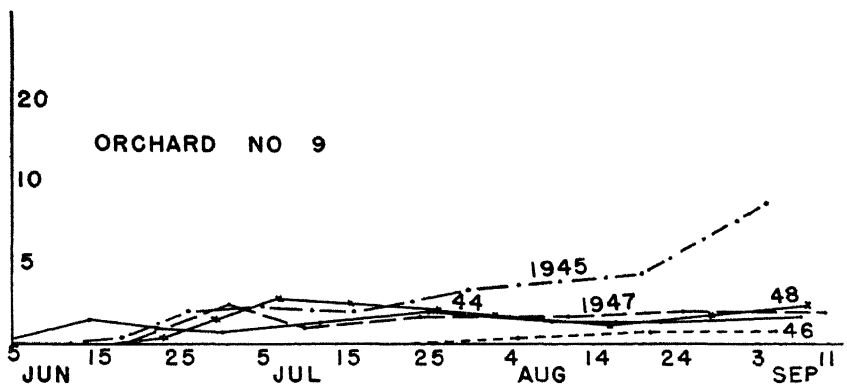

Figure 16 — Seasonal codling moth infestation, orchard 9. 1944-1948. Even in this well sprayed and thinned orchard, the effect of the light crop of 1945 is noticed.

to decrease the amount of spray per tree and skip trees that were bearing only a few fruits. In 1945 and 1946 no sprays were applied after early July. Increased injury at the end of these seasons resulted. Use of corn cobs and corn fodder as mulch materials and the packing shed adjacent to the orchard have also favored the codling moth.

Orchard No. 12

Difficulties with codling moth control started several years before this study was undertaken and continued during 1944 and 1945. A definite resistance to lead arsenate had developed. Excellent control, secured as soon as DDT was used as the insecticide, shows this to be true. This result was obtained even when the number of spray applications was greatly reduced. Control was maintained by good spray practice and using the correct material in adequate amounts.

Orchard No. 13

This is one of the more productive orchards included in the study. However, codling moth had developed a definite resistance to lead arsenate as indicated by records of injury in 1944 and 1945. Eleven cover sprays of lead arsenate were used in 1945 with little effect. Since that time DDT has been used and successful control obtained. The combination of lead arsenate and DDT in second and third cover sprays in 1948 was apparently successful in

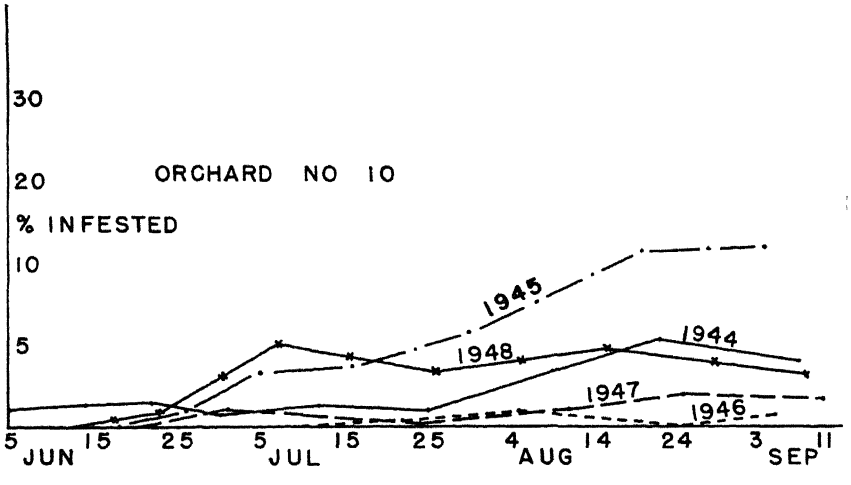

Figure 17 — Seasonal codling moth infestation, orchard 10. In 1948, lead arsenate was used against first brood codling moth. Note improvement in control when DDT replaced it in second brood sprays of that year.

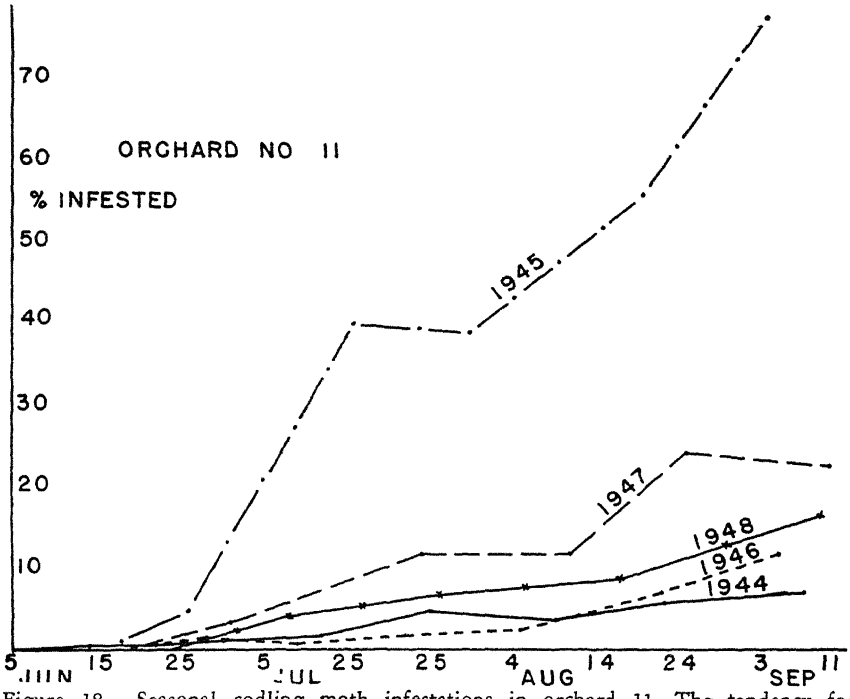

Figure 18 — Seasonal codling moth infestations in orchard 11. The tendency for increasing infestation at the end of the season is due to shorter spray schedules than are usual for this area. Lead arsenate only was used in 1944, 1945 and 1947.

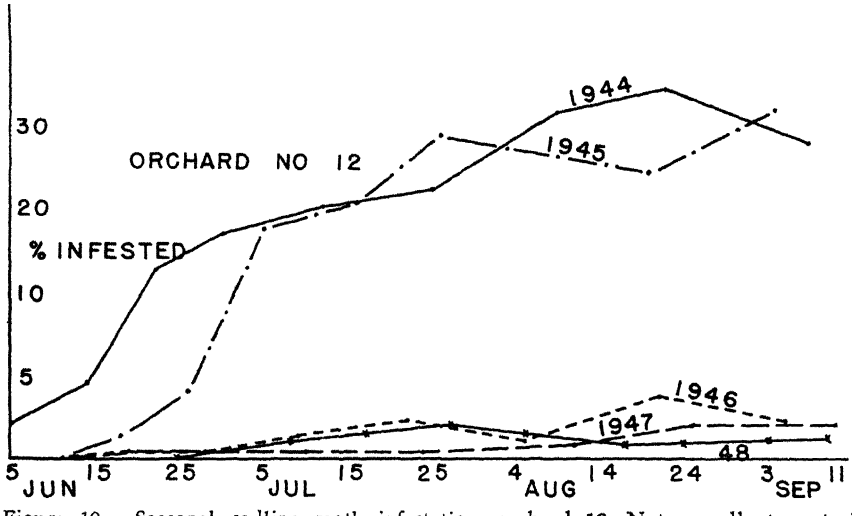

Figure 19 — Seasonal codling moth infestation, orchard 12. Note excellent control with DDT schedules in 1946, 1947 and 1948.

controlling both codling moth and leaf roller. Despite the uniform production record of this orchard, greater difficulty in control is noted in the years of decreased crops.

Orchard No. 14

A long record of successful codling moth control is held by this orchard. The insect has not developed resistance to lead arsenate, although when the orchard changed hands in 1947 the new owner changed to DDT. Primary factor in successful control in this orchard seems to be that the insect has never been permitted to build up. This has been accomplished by an unrelaxed program of good spraying.

Orchard No. 15

This orchard has also had a long record of successful insect control. The apple planting was originally a home orchard and, as such, received little attention. All pests were present in injurious numbers. When the owner entered commercial apple production, a thorough job was done in the insect

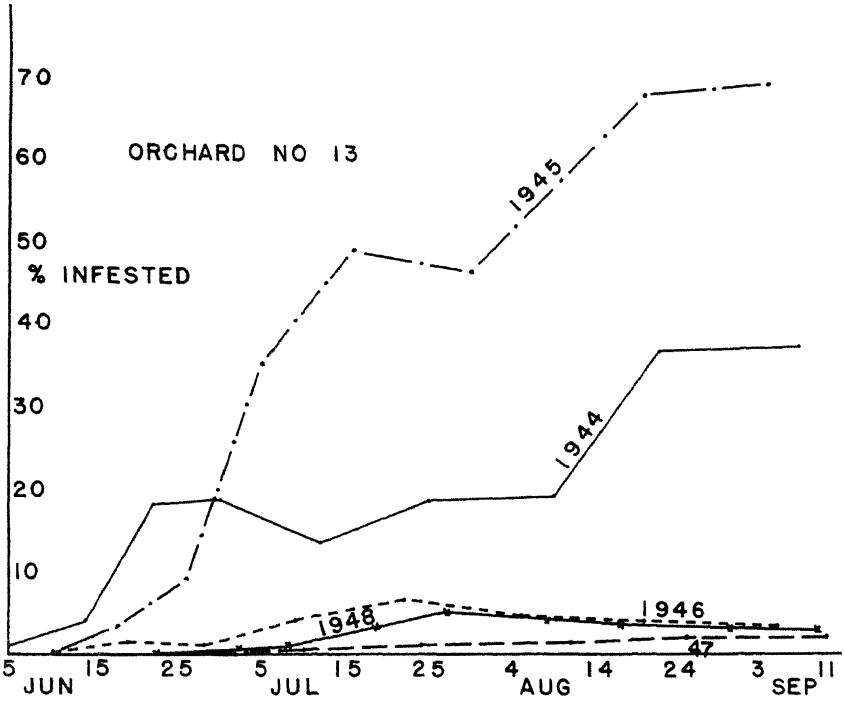

Figure 20 — Seasonal codling moth infestation, orchard 13. Note good control when DDT was used.

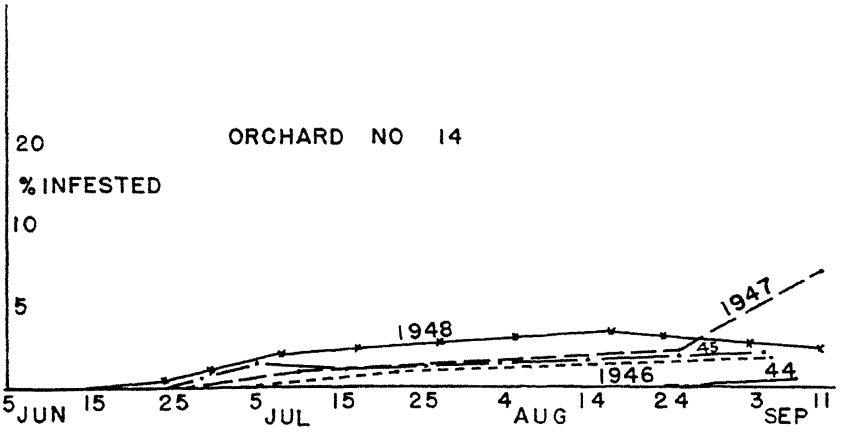

Figure 21 — Seasonal codling moth infestation, orchard 14, 1944-1948, inclusive.

control field, and since then all pests including codling moth have been held to very low numbers. Codling moth must be present in reasonably large numbers if it is to increase in the face of a good spray program. It is believed that codling moth has never been numerous enough here to make this increase. That is the main factor in control. The small size of the orchard is also a favorable factor. Lead arsenate has always been the insecticide used.

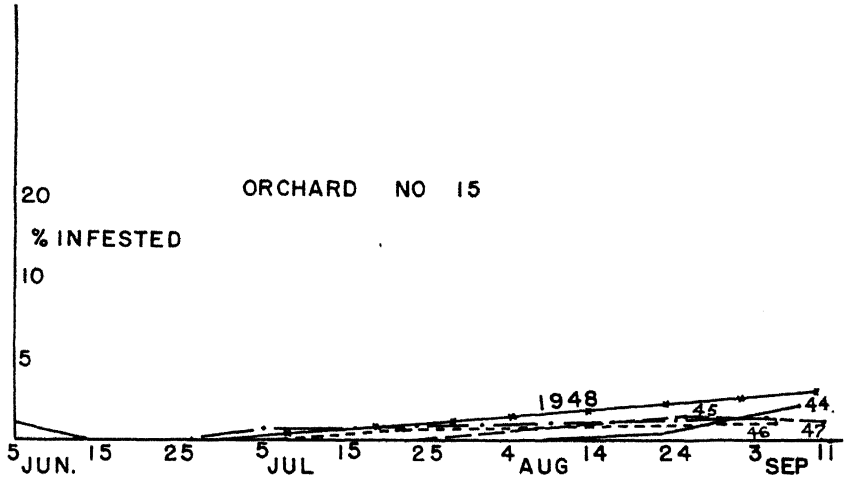

Figure 22. Seasonal codling moth infestation, orchard 15. Note excellent control although lead arsenate has been the only insecticide used.

Discussion of Results

PRACTICES THAT CAN BE CONTROLLED IN INDIVIDUAL ORCHARDS

Apple varieties. During the course of experimental work with codling moth it has been determined that some varieties of apples are more susceptible to attack than others. Listed among more susceptible kinds are Fameuse, Cortland, McIntosh, Red Delicious, Opalescent, Chenango, Wolf River, Maiden Blush, Paradise Sweet, and Rambo. Varieties somewhat resistant are King David, York, Arkansas, Winesap, and others that are seldom grown commercially.

Growers in the Ottawa county area recognized this factor and during the course of the study McIntosh and Fameuse trees were removed by two growers (orchards number 6 and 7) because of difficulty in codling moth control. In two other orchards, not included in the study, Cortland trees were removed for the same reason. Most of the commercial varieties grown in the area are not considered as being particularly susceptible and the factor does not seem to be so important, especially since the wide use of DDT has afforded good protection to all.

Aside from the factor of susceptibility, varieties play another very important part. In another section of this bulletin it is shown that far better percent control of codling moth may be secured when the trees carry a good crop of fruit. Since loss of crop or a poor crop is frequently due to poor pollination, varieties with good annual production records are preferred. Such varieties do not have severe pollination problems.

In this respect, productive trees in the orchard may be a positive factor in codling moth control.

Culture. Orchards using mulch, sod mulch, or either of these systems with centers which were occasionally cultivated were included in the survey. None were cultivated. There was no correlation between any of these systems of culture and results in codling moth control. In orchard number 11 use of coarse mulch material (corn cobs and corn fodder) is thought to have added to the difficulty of the problem. However, in orchards using grass or straw as a mulch, no unusual difficulties in control were noted.

Pruning. In the fifteen orchards studied, many different types and degrees of pruning were encountered. Orchard number 3 used heavy pruning to develope a smaller tree which is easier to spray and harvest. Advantages of the smaller tree did not include good codling moth control. Other orch-

ards with larger, thicker trees were also controlling codling moth, apparently by more attention to spraying. Orchards numbers 9 and 12 were more openly pruned than were numbers 10, 14, and 15, but control was good in all because of careful spraying. There is an advantage in open pruned trees, but good control may be achieved even with poor pruning by efficient application of sprays.

In the actual pruning operation, making smooth cuts will minimize creation of favorable cocooning quarters for codling moth larvae.

Thinning. In years of normal or heavy apple production, thinning of fruits is almost a necessity if a crop of high quality is to be produced. When thinning is being done, most growers remove fruits injured by codling moth and other insects as well as excess apples. The extent to which this practice will aid in codling moth control is not fully known. Unfortunately the light crops produced during this study plus the acute labor shortage caused a marked decrease in thinning, especially from 1945 to 1948, inclusive. Even in 1944, when thinning was practiced only six growers used it to any extent. Orchard number 7 used German war prisoners for thinning and a marked reduction in infestation followed. Figure 14. Some thinning was done in the same orchards in 1947 and a reduction in injury followed. Orchard number 9 was also thinned, but the practice was applied over a much longer period and results do not show so clearly on the infestation graph. Other orchards where thinning was practiced were not bothered to any extent by the codling moth so results were indefinite.

Orchard number 8 thinned off injured fruits in 1946, 1947, and 1948. Thinning was used over a long period and undoubtedly aided in codling moth control. Orchard number 10 used this same type of thinning successfully in 1946 and 1947.

It is felt that thinning off insect-injured fruits and removing them from the orchard can be a definite aid in codling moth control. However, it is an expensive process.

Orchard sanitation. Such practices, as (1) storing of props or fire wood in the orchard, (2) use of coarse or wooden materials as mulch, (3) placing of buildings in the orchard, and (4) permitting unsprayed apple trees to stand adjacent to the orchard may be considered as poor sanitation practices. In the Ottawa county area scraping and banding trees with treated bands has never been widely practiced. Although it has been advised frequently, growers consider it laborious and ineffective and the writer agrees with this opinion.

During the study, several instances were noted where props and firewood were piled in the orchard (orchards numbers 5, 6, 8, and 11). Definite instances of increased infestation by codling moth were noticed around two such piles. This practice should be discouraged.

In orchard number 11, codling moth larvae were found spun up in corn cobs and corn fodder used as a mulch. Similar findings have been reported where coarse wood shavings were used. Such materials should not be used for mulching.

Probably the most serious violation sanitary rules occurs when the packing sheds (or other buildings) are placed in the orchard. Increased trouble due to this was noted in orchards 7, 8, 11, 12, 13, and 14. Larvae are brought to the packing shed in the apples and before such fruit is disposed of larvae leave the apples and find cocooning quarters in the building. Dryness of such quarters causes these larvae to transform and emerge at dates later than normal. This makes egg laying and hatching cover a much longer period and adds to the difficulty of timing the spray schedule. Buildings should not be located in the orchard and the packing shed particularly should be some distance away.

Baskets, racks, ladders, crates, boards, sacks, and any other type of material likely to furnish hibernating quarters for larvae should not be permitted to remain in the orchard.

Presence of neglected apple trees adjacent to commercial orchards is always a source of worry to the grower. Such trees may serve as a breeding place for many different insects which later migrate into the commercial or cared for planting. Orchards numbers 2, 3, 4, and 15 were adjacent to neglected plantings, and orchard 9 was close to one. In all, there was some increase in codling moth damage in the area adjoining the unsprayed trees. Orchard number 3 was most severely injured although even here the additional injury seemed to extend into the orchard for only about two rows. In the other orchards, the additional damage was very light and not a factor in successful apple production. Evidence indicates that where a good spray program is applied, and especially where DDT is used, unsprayed adjacent trees need not be feared.

Crop handling. From the standpoint of codling moth control, crop handling is primarily concerned with the legnth of time that apple fruits, either "windfalls" or "picks" remain in the orchard. Practically all the growers in Ottawa county leave windfalls on the ground until all fruit is harvested after which they are picked up. Many larvae complete their growth and leave the apples during this period. However, the expense of frequent

collections of windfalls fruits prohibits the correction of this difficulty. In some instances the harvested fruit and collected windfalls are left in the orchard for several days, or are placed in a building in the orchard, before being taken to the packing shed. This is not recommended. All fruit should be removed from the orchard as soon as possible. It is believed that this practice has aided control in orchards numbers 10, 12, and 14.

Interplanting. None of the cooperating orchards were interplanted either with stone fruits or with early varieties of apples, therefore, no data were collected as to the effect of this practice on codling moth control. Experiences in many other inter-planted orchards show that good insect control is more difficult to obtain. This is principally due to the difficulty of spray schedule arrangement and application.

SPRAYING

Spraying is the most important measure in control of codling moth and other insects and diseases. The grower is in control and he is largely responsible for its success or failure. This is especially true since the introduction of efficient, present-day insecticides. Influencing the degree of success or failure by spraying are several factors that should be considered separately.

(1) **Equipment.** If time were not a factor, a tree could be sprayed thoroughly with almost any kind of sprayer. Because speed in coverage is important, spray equipment of adequate quality and quantity to cover the orchard in 4 to 5 days should be at hand. For large orchards, especially, there should be some reserve equipment in case of breakdowns. Numerous failures in codling moth control have been due to the fact that the entire orchard could not be sprayed during critical periods. A study of spray machinery owned by growers showed that, with one possible exception, the equipment was adequate. Therefore, the factor of spray machinery was not important in the codling moth control program in Ottawa county.

(2) **Coverage.** Poor coverage may be due to uneven applications of spray material to the tree or to the use if insufficient amounts. Uneven application results in the "spotty" appearance of the spray as applied by inexperienced or careless spraymen. This difficulty can usually be corrected by practice or by skillful use of mechanical sprayers. Generally, spray coverage in Ottawa county was even.

The amount of spray necessary to cover a tree thoroughly is debateable although numerous authorities consider that trees over 20 years old should receive about one gallon of dilute spray for each year of their age.

Results of the Ottawa county study indicate this may be a larger amount than is actually necessary. Exact figures on the gallonage used were not received from all cooperating growers but several furnished accurate figures extending over the entire five-year period. (Orchards numbers 9, 10, 12, 13, and 14). Other orchards furnished partial records. A summarization shows there was a wide range in amounts of spray used in terms of gallons of spray per year of the tree's age. Seasonal records varied from .18 gallons, or about one and one-half pints, to 1.2 gallons. In these extreme cases one grower was using more than six times as much spray per year of age of his trees than was the other. Furthermore, there was not a great deal of difference in the age and size of the trees in the two orchards. The orchard where the low amount of spray was used had difficulty in controlling both insects and disease.

By comparison, several orchards achieved good control with modest amounts of spray as shown by the spray gallonage records of orchards numbers 9, 10, and 14. In orchard 10, the gallons of spray used per each year of the tree's age averaged about 0.4 but excellent control was obtained due largely to the care and skill with which the applications were made. The orchards using large amounts of spray were all quite successful in their control efforts. Sufficient gallonage is important although skillful epplication will enable smaller amounts to be used successfully.

(3) **Correct timing.** Best results are obtained when the state of biological development of the insect is known and used in connection with weather conditions. Applications of spray should be made to coincide with periods of greatest insect activity. In Otawa county where codling moth egg hatching usually extends over a seven week's period, fruits must be fully protected during this entire time.

With DDT this can be accomplished by spraying every two weeks. The date of the first of these sprays is recommended by the Agricultural Extension Service, as is also the date for the first of the second brood sprays. Ottawa county growers frequently fail to get the best timing because of waiting too long for the wind to change. One side of the trees will be sprayed according to recommendations and the other side delayed for a wind change. For effective results, both sides should be sprayed within a very few days. Instances have been recorded where growers have waited two weeks for the wind to change. Such practices have resulted in much additional insect damage. If the wind does not change in a few days the opposite sides of the trees should be sprayed despite this difficulty.

(4) **Spray materials.** Cooperating growers have followed rather closely the state recommendations regarding use of insecticides. No exceptions to

this rule were noted. Difficulties in codling moth control cannot be blamed on the use of improper materials.

Results from this study developed the present recommendation that hydrated lime be omitted from combinaions of wettable or flotation sulfur and lead arsenate. For many years the Ohio spray schedule included hydrated lime with all sulfur-lead combinations. This was probably a carry over from the days when liquid lime-sulfur was almost the only fungicide to be used with lead arsenate.

However, as early as 1943, when some preliminary work was done on this project, lime was being omitted from wettable sulfur-lead arsenate sprays in a few orchards. The fruit and foliage in these were in good condition and the conclusion was reached that the lime was probably unnecessary. Several of the cooperating orchards omitted lime in 1944 and a test block of this character was included in experimental work at Wooster. Again good results were secured. Further enlarged tests in 1945 and 1946 confirmed these results and in 1947 the recommendations was made for the entire state that lime be omitted from such combinations. Lime, however, is retained where liquid lime-sulfur and lead arsenate are used.

This recommendation has found wide use in Ohio and has saved growers thousands of dollars for material as well as decreasing the cost of sprayer upkeep. Hydrated lime is abrasive and valves, cylinder walls, and packing, are affected by its use.

Effects of changing from lead arsenate to DDT. The first recommendation for the use of DDT in sprays against the codling moth in Ohio was made in 1946. It was advised that the material be used only in those orchards where the economic control of the insect by lead arsenate was impossible. As most of the orchards in Ottawa county were in this classification, DDT was widely and successfully used that season. Since 1946 the use of DDT has continued. What have been the effects of this large scale change in spray materials?

Undoubtedly all insects or other pests on apple were affected by the change to DDT. However, striking or obvious effects were noted only in the cases of four or five pests. As already pointed out codling moth damage was greatly reduced by its use and leaf hopper populations were almost entirely eliminated. On the other hand, some pests increased greatly in the DDT treated orchards. In 1944 and 1945 when lead arsenate was the main insecticide only one orchard (number 14, 1944) was infested to a serious extent by the European red mite. In 1946 ten of the cooperating orchardists used DDT while five continued with lead arsenate. The results are depicted

in Figure 23. This great increase in mite populations and damage was most marked in 1946. In 1947 and 1948 mites continued to be much more severe than in 1944 and 1945 but were less injurious than in 1946. The major factor in this reduction was the use of acaricides by growers and also a measure of biological control. Nevertheless the use of DDT has apparently produced a major problem in the control of orchard mites.

Another problem that has been aggravated by the use of DDT is that of the red-banded leaf roller. This is a native insect but in orchards sprayed with lead arsenate it was practically unknown. In Ottawa county several of the DDT treated orchards have suffered appreciable injury due to this leaf roller. In general, the greater the number of DDT applications, the greater the injury. The addition of lead arsenate to certain DDT sprays will prevent commercial damage. Also two of the new spray materials, parathion and the DDT analog, DDD, are very effective against this pest.

To sum up the situation, use of DDT has solved two problems, but in turn two more have been created. Fortunately definite progress has been made in the solution of these last two.

Spraying young trees. No young orchards were included in this study. However, numerous young trees, non-bearing, or capable of bearing only a

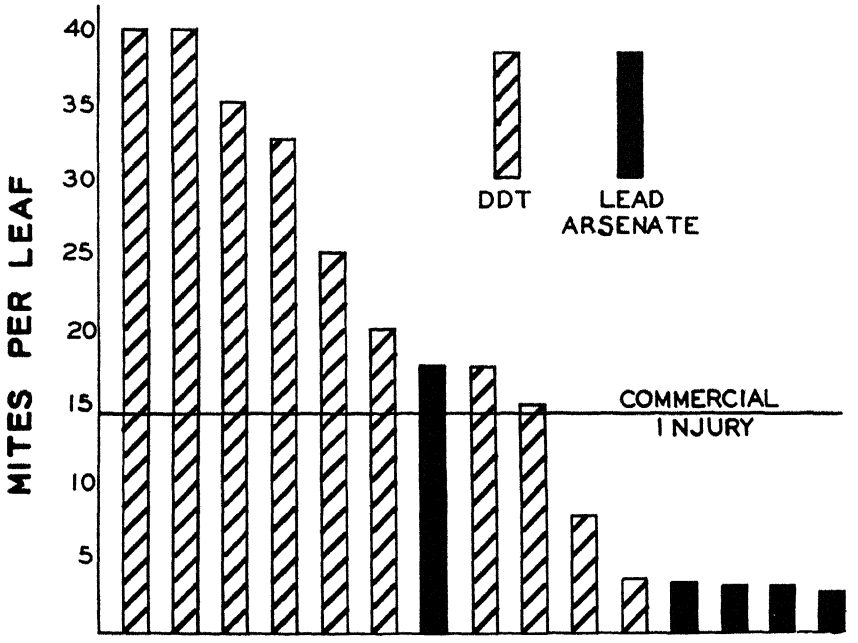

Figure 23 — European red mite injury in orchards sprayed with DDT as contrasted with that occurring in orchards sprayed with lead arsenate.

few apples, were found as replants in many of the orchards. These were sprayed with the same schedules as the bearing trees. This is good practice and it should be used on all orchards just beginning to bear. It will prevent the establishment of many insects that would entrench themselves if first scattering crops were unsprayed.

Alternatives to good spraying when crop is very short. The apple crop is occasionally so light that it will not pay the cost of adequate protection by spraying. Such a condition may be met (1) by spraying at a loss, (2) by thinning off all fruits early in the season, or (3) by simply abandoning the crop.

Some experiences during the five years in Ottawa county shed some light on the best possible course to follow during short crop years. Several crops have been sprayed and grown at a loss. Instances of this are orchards numbers , 3, 5, 11, and 14 in 1945 and orchard 6 in 1948. Some growers believed that overall they were better off by following this course. Others consider that they could have abandoned the crop or thinned off the fruits to advantage.

In the beginning of the 1945 season a large block of young trees in orchard 6 set only a few fruits, estimated at less than 2 percent of a normal crop. Spraying was stopped after the petal fall and in late June workmen went over all trees removing visible fruits. From 0 to 110 fruits per tree were removed from 249 17-year-old trees at a cost of $36.00. On July 16 the writer and an assistant examined about 60 trees on which were found 411 fruits of which 145 were wormy. As the 60 trees examined were about one-fourth of the total number, there were probably about 1600 fruits in the orchard of which 600 were wormy.

In 1946, this orchard set a rather light crop which was sprayed with particular attention given to the trees with the best crop. At the end of the season 4 percent of the fruit was injured by codling moth.

In 1945 one section of orchard 11 set a very light crop and was practically abandoned after the petal fall spray. At harvest time, over 80 percent of the few remaining fruits were wormy. In 1946, the crop in this block was not large but it was sprayed only to July 2 at which time approximately one percent of the fruit was injured by codling moth. However, due to the cessation of spraying, 11.7 percent of all fruit was injured by harvest time. There is little doubt that if spraying had been continued infestation would have been below five percent. In connection with other work in Ohio, several other cases in which light crops have been abandoned were observed. The results rather closely paralleled those of the cases in the Ottawa county study.

The principal objection to abandoning a crop without thinning off the fruit is the assumption that the various pests will increase unduly and prove troublesome in following years. The Ohio experiences have not borne out this idea. In general, good spraying has just as effectively controlled pests, particularly the codling moth, in years following abandonment as under the usual circumstances. The necessary number of fungicidal sprays required to protect the orchard against disease must be made, but otherwise spraying can be discontinued. The present availability of effective spray materials such as DDT further adds to our surety in this belief.

SUMMARY AND CONCLUSIONS

Factors beyond the control of the individual grower:

1. In the Ottawa county area the growing season is characterized by lower temperatures in May and June and by higher temperatures in August and September than ordinarily occur in other sections of the state. This results in the occurrence of a greater proportion of the codling moth damage in late season.

2. The life history of the codling moth in this area is marked by a heavy winter carryover of larvae, a high percentage coming from first brood larvae of the preceding growing season. Midsummer brood moths are therefore less numerous than was previously thought. However, the damage done by larvae from this brood is great, due to favorable temperature conditions.

3. The orchards are grown on many different soil types but there was no correlation between soil type and codling moth infestation.

4. Orchards are larger, more numerous and concentrated in some parts of the area. Where such concentrations as this prevail, the codling moth is more difficult to control than in areas of smaller, more isolated orchards.

5. The size of the apple crop varied from 47 to 15 percent of full production during the period of this study. In years of light crops (i. e. 1945 and 1948), the difficulties of codling moth control were tremendously increased.

6. The codling moth has developed resistance to lead arsenate in a majority of the orchards. The degree of resistance varies in different plantings. The failure of lead arsenate to control the codling moth is the reason for the rapid change from lead arsenate to DDT which occurred in 1946.

Factors over which the grower may exercise control:

7. Orchards studied ranged from 10 to 35 years of age. In general, more difficulty in controlling codling moth was experienced in the older orchards.

8. Numerous varieties, differing in their susceptibility to codling moth attack and in their ability to pollinate and set fruit, are grown. Since good crops are essential to economic codling moth control, varieties should be planted that will cross pollinate and set fruit. With the newer spray chemicals it is felt that control of codling moth can be secured even on susceptible varieties.

9. Sod and sod mulch systems of culture are prevalent in the area. In general they have no bearing on the degree of codling moth control obtained.

10. There is much diversity in the amount and type of pruning practiced in the different orchards. Good pruning is a decided aid to good spraying. However, excellent control of codling moth can be obtained by thorough spraying even when trees are in dense growth.

11. During the years of this study fruit thinning was a minor practice. However, several cases were noted in which this practice was an aid in codling moth control.

12. Sanitary practices were generally good except for the presence of buildings in several orchards. Around such buildings, and especially before the advent of DDT, codling moth was more difficult to control. Scraping and banding of trees was not considered a practical measure by the growers.

13. In harvesting or handling the crop, most growers collect dropped fruits once, at picking time. The picked fruit is usually promptly removed to the packing house, but may remain there for varying lengths of time. If the packing house is in or adjacent to the orchard, many larva will leave the fruit and find wintering quarters in the building from which they will later fly to the orchard. The prompt packing and disposition of all fruit is highly recommended.

14. Most growers had adequate spray equipment. No correlation between type of equipment and degree of control was found.

15. The majority of growers apply the spray so that a fairly even coverage is obtained. However, many growers do not use enough spray gallonage. There is no more important factor in securing control of insects and diseases than the use and even distribution of adequate amounts of spray.

16. Most sprays are started on time but, due to the practice of waiting for the wind to change, completion is frequently behind schedule. Much better results are obtained if the spray application is completed within a short period of time. Some growers spray during the period of inactivity between broods. This is not an economic practice.

17. Standard recommended insecticides were used by all cooperating growers. DDT was far more efficient in codling moth control than was lead arsenate or the nicotine-oil combinations.

18. The spray schedules used by the different growers varied greatly in the combinations of insecticides and fungicides, and in the number of spray applications that were made. No definite correlations could be drawn between these variations and the degree of control that was secured.

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APPENDIX

Grower Control of Codling Moth

It has been impossible to present in detail the large volume of data taken during this study. However, this has been summarized and the basic material from which many of the conclusions were drawn is presented in tabular form in the Appendix.

OPERATIONAL DATA — OTTAWA COUNTY ORCHARDS

Table 7, acreage, No. of trees, age, and varieties

Orchard No.	No. of acres	No. of trees	Average age of trees in 1944	Principal Varieties—In order of numbers
1	12	534	16	Jonathan, Red Delicious, McIntosh Cortland, Baldwin
2	60	2400	20	Jonathan, Red Delicious, McIntosh, Baldwin
3	25	1500	24	Red Delicious, Stayman, Jonathan, Golden Delicious
4	8	390	20	Cortland, Jonathan, McIntosh, Red Delicious, Stayman
5	10	250	30	Baltimore, Rome, Jonathan, Northern Spy
6	14	377	20	Baldwin, Stayman, Jonathan, Red Delicious, Rome, Grimes
7	40	1600	20	Baldwin, Red Delicious, York, Jonathan, McIntosh
8	50+	1550	28	Baldwin, Jonathan, Red Delicious, Stark, Wealthy
9	6	162	20	Golden Delicious, Red Delicious, Jonathan, Stayman, Grimes
10	40	1356	15	Stayman, Jonathan, Red Delicious, Baldwin
11	21	645	17	Rome, Stayman, Cortland, N. W. Greening, Baldwin, others
12	40	1507	18	Red Delicious, Golden Delicious, Jonathan
13	29	800	16	Jonathan, Grimes, Golden Delicious, McIntosh, Stayman, Red Delicious, others
14	17	606	23	Jonathan, Stayman, McIntosh, Baldwin, Red and Golden Delicious, Grimes
15	6.2	225	30	Rome, Jonathan, Stayman, Red Delicious, others

Table 8. Soils, culture, pruning, and thinning

Orchard No.	Soil type	Culture	Pruning	Fruit thinning
1	Danbury clay loam	Sod mulch	Light but even	In 1944 only
2	Catawba silt loam	Sod mulch centers broken occasionally	Light, many thick trees	None
3	Catawba silt loam and Randolph stony loam, others	Sod and sod mulch	Severe, low, open trees	None
4	Same as orchard 3	Sod and sod mulch	Light, trees not open	Occasionally practiced on loaded trees
5	Toledo silty clay	Sod	Light, even but thick	None
6	Toledo silty clay & Toledo clay loam	Sod	Medium, fairly open	None
7	Toledo silty clay	Sod. Centers broken occasionally	Medium, fairly open	Practiced in 1944, 1946, 1947
8	Toledo silty clay	Sod. Centers broken at times	Medium, fairly open	Practiced in years of full crops
9	Toledo and Bono silty clay	Sod mulch	Well opened trees	Practiced whenever trees have full crops
10	Toledo silty clay	Sod mulch	Well opened trees	Practiced in years of full crops
11	Toledo silty clay	Sod mulch	Lightly pruned	None
12	Toledo and Bono silty clay	Sod mulch	Well opened trees	Not a general practice
13	Fulton silty clay loam and Toledo silty clay	Sod mulch Centers occasionally broken	Well opened trees	Practiced occasionally on part of orchard
14	Toledo silty clay	Same aas 13	Fairly open trees	Practiced in years of heavy crops
15	Toledo silty clay and Fulton silty clay loam	Same aas 13	Open trees	Not generally practiced

Table 9. Orchard Sanitation

Orchard No.	Adjacent apple orchards	General sanitation	Crop handling
1	One pear orchard, no others nearby	Good, no buildings	Drops collected once, picked fruit taken immediately to packing house outside of orchards
2	Several adjacent apple orchards	Good, no buildings	Same as orchard 1
3	Several, one unsprayed	Good, no buildings	Same as orchard 1
4	Several, one unsprayed	Good, no buildings	Same as orchard 1
5	None nearby	Fair, no buildings, poison ivy and stored wood in orchard	Same as orchard 1
6	None nearby	Good, no buildings, much poison ivy	Same as orchard 1
7	One adjacent, numerous others within one mile	Good except for old packing house in orchard	Same as orchard 1
8	Several adjacent orchards	Good except for several buildings in and adjacent to orchard	All fruit brought to packing plant at edge of orchard
9	One small nearby apple orchard	Excellent	Same as 8
10	None nearby	Good, some buildings at edge of orchard	All fruit taken direct from orchard to central packing house
11	Two adjacent orchards	Fair, mulch of coarse materials & buildings adjacent to orchard	Fruit graded in packing shed at orchard's edge
12	None nearby	Good, packing house at orchard's edge	All fruit handled in home packing house
13	One adjacent	Good except for packing shed and other buildings in orchard	Fruit graded and stored in home packing plant
14	One adjacent	Good except for packing shed in orchard	Usually packed at orchard
15	Two adjacent	Good, some buildings near orchard	Packed at home packing shed

Table 10. Spray Machinery

Orchard No.	Type	No. of sprayers	Gallons per minute	Usual Pressure	Size of tank	No. of men spraying	Position for spraying
1	High pressure	1	20	450	300	1 or 2	Top of tank
2	Airblast (speed sprayer)	1	50	Low rotary pump	500	1	Mechanical
3	High pressure 1944-1947	1	9	350	150	1	From tractor seat
	1947	1	20	450	300	1	From tractor seat
4	High pressure	1	20	500	300	1	From top of tank
5	High pressure	1	20	450	300	1	From top of tank
6	High pressure	1	20	350	300	1	From top of tank
7	High pressure		30	500	300		One on top of sprayer or in tower, other on low platform
		2	35	600	400	2	
8	High pressure		35	600	400		
		2	35	600	400	1 or 2	From top of tank
9	High pressure	1	20	450	200	1	From top of tank
10	High pressure	1	20	400	300	1	From top of tank
11	High pressure	1	20	600	200	1	From top of tank
12	High pressure	1	55	600	600	2	From top of tank and low platform
13	High pressure (also one duster)	1	20	600	300	2	One in tower, other in lower position
14	High pressure	1	20	500	200	1	From top of tank
15	High pressure	1	20	600	300	1	From top of tank or lower

SEASONAL DATA—Ottawa County—1944-48, inclusive

The data secured each year from each of the orchards under study have been summarized and are presented in the following tables which are self-explanatory.

Table 11. Seasonal Data.

	1944	1945	1946	1947	
Orchard 1					
Percent of full crop	75	5	50	45	35
No. of cover sprays	9	5	8	5	6*
Coverage	good	Poor	Good	Good	Good
Percent of codling moth infested fruit	4.3	44.3	1.3	1.7	5.0
European red mite	V. Light	Light	Light	Light	Light
%Red-banded leaf roll	None	None	None	Trace	1.0%
* Two dust applications counted as two sprays.					
Orchard 2					
% crop	40	8	60	15	10
No. of cover sprays	—	11	7	5	5
Coverage	—	Good	Good	Good	Poor
% of Codling Moth	—	84.5	2.7	2.7	43.0
European red mite	—	V. Light	Medium to Severe	Severe	Medium
%Leaf roller	—	None	None	Trace	4.0
Orchard 3					
% crop	15	8	20	25	20
No. of cover sprays	6	6	4	4	5
Coverage	Average	Poor	Average	Average	Average to Good
% codling moth	17.3	72.0	10.0	18.5	22.0
European red mite	Light	Light	Some	Severe	Light
% leaf roller	None	None	None	Trace	Trace
Orchard 4					
% Crop		25	75	35	30
Cover sprays		7	6	6	7
Coverage		Good	Good	Good	Good
% codling mith		27.6	.3	1.0	3.0
European red mite		Light	Severe	Medium to Severe	Medium to Severe
%Leaf roller		None	None	Trace	Trace

	1944	1945	1946	1947	
Orchard 5					
% of full crop	30	10	30	35	10
No. of cover sprays	7	7	6	5	5
Coverage	Fair	Poor	Fair	Poor	Poor
% codling moth	23.3	64.0	12.5	25.0	43.0
European red mite	Light	Light	Severe	V. Severe	Light
% Leaf roller	None	None	None	Trace	3%
Orchard 6					
% full crop	25	15	18	20	5
No. of cover sprays	7	5	6	4	4
Coverage	Fair	Poor	Poor	Fair	Poor
% codling moth	18.0	47.0	15.0	3.0	48.0
European red mite	Light	Light	Medium	V. Severe	Light
% Leaf roller	None	None	None	Trace	1%
Orchard 7					
% of full crop	60	15	35	40	25
No. of cover sprays	6	6	7	6	5
Coverage	Good	Fair	Good	Good	Fair
% of codling moth	9.0	56.0	4.0	4.0	9.5
European red mite	Light	Light	Severe	Severe	Light to Medium
% Leaf roller	None	None	None	Trace	10%
Orchard 8					
% Crop	40	30	45	40	20
No. cover sprays	6	7	6	6	6
Coverage	Good	Good	Good	Good	Good
% Codling moth	32.0	28.6	9.3	2.0	4.0
European red mite	Light	Light	Severe	Severe	Light
% Leaf roller	None	None	None	Trace	6%
Orchard 9					
% Crop	60	20	60	30	35
Cover sprays	8	8	7	6	6
Coverage	Good	Good	Good	Good	Good
% codling moth	1.6	8.6	.7	1.6	2.3
European red mite	V. Light	V. Light	Light	Med. to Severe	V. Light
% Leaf roller	None	None	None	None	Trace

	1944	1945	1946	1947	
Orchard 10					
% .Crop....	70	10	20	50	30
Coversprays	8	8	5	5	6
Coverage	Good	Good	Good	Good	Good
% Codling moth	4%	12%	.7	1.6	3.3
European red mite	V. Light	V. Light	V. Light	Some Damage	V. Light
% Leaf roller	None	None	None	1%	Trace
Orchard 11					
% Crop	40	8	50	20	20
Cover sprays	4	3	3	4	5
Coverage	Fair	Poor	Fair	Fair	Fair
% Codling moth	7.0	77.5	11.5	20.0	16.3
European red mite	Light	Light	Medium	Medium	Medium
% Leaf roller	None	None	None	None	Trace
Orchard 12					
% Crop	30	10	10	25	30
Cover sprays	8	8	7	5	4
Coverage	Good	Good	Good	Good	Good
% Codling moth	28.3	32.2	2.3	2.0	1.3
European red mite	V. Light	V. Light	Light	Medium	V. Light
% Leaf roller	None	None	None	None	Trace
Orchard 13					
% Crop	40	35	45	65	20
Cover sprays	9	11	7	5	6
Coverage	Good	Good	Good	Good	Good
% Codling moth	37.6	70.0	3.3	2.0	3.0
European red mite	Light	Light	Medium	Medium to Severe	Light to Medium
% Leaf roller	None	None	None	None	Trace
Orchard 14					
% Crop	70	8	15	50	30
No. of cover sprays	5	5	4	7	6
Coverage	Good	Fair	Fair	Fair	Good
% Codling moth	.3	2.0	1.7	7.0	2.3
European red mite	Medium to Severe	V. Light	V. Light	Medium to Severe	V. Light
% Leaf roller	None	None	None	Trace	2%
Orchard 15					
% Crop	40	15	15	20	25
Cover sprays	5	5	5	3½	4
Coverage	Good	Good	Good	Good	Good
% Codling moth	2.0	1.3	1.0	1.0	3.0
European red mite	Light	Light	V. Light	Light	V. Light
% Leaf roller	None	None	None	None	Trace

Spray Schedules, Ottawa County, 1944-48 Inclusive

The spray schedules for all orchards included in this study are summarized and presented in the following tables. The insecticides used are designated by the following abbreviations: L.A.=Lead Arsenate; DDT=dichloro-diphenyltrichloroethane; N.S.=nicotine sulphate; F.N.=fixed nicotine. No other insecticides used.

Table 12. Summarized Spray Schedules, Insecticides Only.

	1944	1945	1946	1947	1948
Orchard 1					
Petal fall	3 L.A.[1]	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
2nd cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
3rd cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
4th cover	3 L.A.	3 L.A.	4 L.A.	1½ DDT	2 DDT
5th cover	4 L.A.	3 L.A.	4 L.A.	1½ DDT	DDT Dust
6th cover	4 L.A.	.....	4 L.A.	.....	DDT Dust
7th cover	4 L.A.	.....	4 L.A.	.....	.....
8th cover	4 L.A.	.....	4 L.A.	.....	.....
9th cover	5 L.A.	.....	.....	.....	.....
Orchard 2					
Petal fall	.....	4 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	.....	4 L.A.	3 L.A.	3 L.A.	3 L.A.
2nd cover	.....	4 L.A.	2 DDT	1½ DDT	3 L.A.
3rd cover	.....	4 L.A.	2 DDT	1½ DDT	2 DDT
4th cover	.....	4 L.A.	2 DDT	1½ DDT	2 DDT
5th cover	.....	4 L.A.	2 DDT	1½ DDT	2 DDT
6th cover	.....	4 L.A.	2 DDT	.....	.....
7th cover	.....	4 L.A.	2 DDT	.....	.....
9th cover	.....	4 L.A.	.....	.....	.....
9th cover	.....	4 L.A.	.....	.....	.....
10th cover	.....	4 L.A.	.....	.....	.....
11th cover	.....	4 L.A.	.....	.....	.....
Orchard 3					
Petal fall	4 L.A.	3 L.A.	3 L.A.	4 L.A.	3 L.A.
1st cover	4 L.A.	3 L.A.	3½ L.A.	4 L.A.	3 L.A.
2nd cover	4 L.A.	3 L.A.	3½ L.A.	3½ L.A.	3 L.A.
3rd cover	4 L.A.	3 L.A.	3½ L.A.	1½ DDT	3 DDT
4th cover	4 L.A.	3 L.A.	3½ L.A.	1½ DDT	3 DDT
5th cover	4 L.A.	3 L.A.	.....	.....	3 DDT
6th cover	4 L.A.	4 L.A.	.....	.....	.....

	1944	1945	1946	1947	1948
Orchard 4					
Petal fall	.....	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	.....	3 L.A.	1½ DDT	3 L.A.	1½ DDT
2nd cover	.....	3 L.A.	1½ DDT	3 L.A.	3 L.A.
3rd cover	.....	3 L.A.	1½ DDT	1½ DDT	1½ DDT
	.....		3 L.A.	3 L.A.	
4th cover		3 L.A.	as above	as above	3 L.A. 1½ DDT
5th cover	.....	3 L.A.	1½ DDT	DDT 5% dust	as above
6th cover	.....	3 L.A.	1½ DDT	DDT 5% dust	1½ DDT
7th cover	.....	3 L.A.	.....	.....	1½ DDT
Orchard 5					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	4 L.A.	3 L.A.	3 L.A.	L.A. Dust	3 L.A.
2nd cover	4 L.A.	3 L.A.	2 DDT	2 DDT	2 DDT
3rd cover	4 L.A.	3 L.A.	2 DDT	2 DDT	1½ DDT
4th cover	4 L.A.	3 L.A.	2 DDT	2 DDT	2 DDT
5th cover	4 L.A.	3 L.A.	2 DDT	2 DDT	2 DDT
6th cover	4 L.A.	3 L.A.	2 DDT	.....	.....
7th cover	4 L.A.	3 L.A.	.....	.....	.....
Orchard 6					
Petal fall	3 L.A.	4 L.A.	3 L.A.	4 L.A.	4 L.A.
1st cover	4 L.A.	4 L.A.	3 L.A.	4 L.A.	4 L.A.
2nd cover	4 L.A.	4 L.A.	3 L.A. 2 DDT	2 DDT	4 L.A.
3rd cover	4 L.A. 1 pt. NS	4 L.A.	2 DDT	2 DDT	2 DDT
4th cover	4 L.A. 1 pt. NS	4 L.A. 3 F.N.	2 DDT	2 DDT	2 DDT
5th cover	4 L.A. 1 pt. NS	4 L.A.	2 DDT	.....	.....
6th cover	4 L.A. 1 pt. NS	.....	2 DDT	.....	.....
7th cover	4 L.A.	.....	.....	.....	.....

	1944	1945	1946	1947	1948
Orchard 7					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3½ L.A.
1st cover	3 L.A.	4 L.A.	3 L.A.	3 L.A.	2 DDT
2nd cover	3% L.A.	4 L.A.	3 L.A.	2 DDT	2 DDT
3rd cover	4 L.A.	4 L.A.	2 DDT	2 DDT	2 DDT
4th cover	4 L.A. ¾ pt. N.S.	4 L.A.	2 DDT	2 DDT	.....
5th cover	4 L.A.	4 L.A.	2 DDT	1½ DDT	1¾ DDT
6th cover	4 L.A.	4 L.A.	2 DDT	1½ DDT	2 DDT
7th cover	.....	.....	4 L.A.	.....	.....
8th cover	.....	.....	.....	.....	.....
9th cover	.....	.....	.....	.....	.....
Orchard 8[2]					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A.	4 L.A.	3 L.A.
2nd cover	4 L.A. 1 pt. N.S.	4 L.A.	1¾ DDT	2 DDT	3 L.A.
3rd cover	4 L.A. ¾g. oil	4 L.A.	1¾ DDT	2 DDT	1¾ DDT
4th cover	3 L.A. ¾g. oil	4 L.A.	1¾ DDT	2 DDT	1¾ DDT
5th cover	4 L.A. 1 pt. oil	4 L.A.	2¼ DDT	2 DDT	2 DDT
6th cover	.....	4 L.A.	2¼ DDT	2 DDT	2 DDT
7th cover	.....	4 L.A. ¾g. oil 1 pt. oil	.....	.....	.....
Orchard 9					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
2nd cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
3rd cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
4th cover	3 L.A.	3 L.A.	3 L.A.	1½ DDT	3 L.A.
5th cover	3 L.A.	3 L.A.	3 L.A.	1½ DDT	1½ DDT
6th cover	3 L.A.	3 L.A.	3 L.A.	1½ DDT	1½ DDT
7th cover	3 L.A.	3 L.A.	3 L.A.	.....	.....
8th cover	3 L.A.	3 L.A.	.....	.....	.....
Orchard 10					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
2nd cover	3 L.A.	3 L.A.	2 DDT	1½ DDT	3 L.A.
3rd cover	3 L.A.	3 L.A.	1½ DDT	1½ DDT	3 L.A.
4th cover	3 L.A.	3 L.A.	1½ DDT	1½ DDT	3 L.A.
5th cover	3 L.A.	3 L.A.	1½ DDT	1½ DDT	2 DDT
6th cover	3 L.A.	3 L.A.	.....	.....	2 DDT
7th cover	3 L.A.	3 L.A.	.....	.....	.....
8th cover	3 L.A.	3 L.A.	.....	.....	.....

	1944	1945	1946	1947	1948
Orchard 11					
Petal fall	3 L.A.	3 L.A. ¾ DDT	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A. ¾ DDT	3 L.A.	3 L.A.	3 L.A.
2nd cover	3 L.A.	3 L.A. ¾ DDT	3 L.A.	3 L.A.	3 L.A.
3rd cover	3 L.A.	3 L.A. ¾ DDT	3 L.A.	3 L.A.	3 L.A.
4th cover	3 L.A.	.....	.....	3 L.A.	3 L.A.
5th cover	.....	.....	.....	.....	2 DDT
Orchard 12[3]					
Petal fall	3 L.A.	3 1/3 L.A.	3 1/3 L.A.	3+ L.A.	3 L.A.
1st cover	3+ L.A.	3 1/3 L.A.	3 1/3 L.A.	3+ L.A.	3 L.A.
2nd cover	3 L.A. 2 F.N.	3 1/3 L.A. ¾ oil	1 3/16 DDT	1½ DDT	1½ DDT
3rd cover	2 F.N. ½g. oil	3 1/3 L.A. ¾g. oil	1 3/16 DDT	1½ DDT	1½ DDT
4th cover	2 F.N. ½g. oil	2 F.N. ½ oil	1 3/16 DDT	1½ DDT	1½ DDT
5th cover	2 F.N. ½g. oil	2 F.N. ½ oil	1 3/16 DDT	1½ DDT	.....
6th cover	2 F.N. ½g. oil	2 F.N. ½ oil	1 3/16 DDT	.....	.....
7th cover	2 F.N. ½g. oil	2 1/6 F.N. ½ oil	1 3/16 DDT	.....	.....
8th cover	2 F.N. ½g. oil	2 1/6 F.N. ½ oil	.....	.....	.....
Orchard 13					
Petal fall	3 L.A.	3 L.A.	3 L.A.	4 L.A.	4 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A. 3 DDT [4]	4 L.A.	2 DDT
2nd cover	3 L.A.	3 L.A.	3 DDT [4]	2 DDT [5]	2 L.A. 2 DDT
3rd cover	3 L.A.	3 L.A.	3 DDT	1½ DDT	2 L.A. 2 DDT
4th cover	3 L.A.	3 L.A.	3 DDT	2 DDT	DDT sulful dust
5th cover	3 L.A. 1 pt. N.S.	3 L.A.	3 L.A.	2 DDT	2 DDT
6th cover	3 L.A.	3 L.A.	3 DDT	.....	2 DDT
7th cover	3 L.A.	3 L.A.	3 DDT	.....	.....
8th cover	3 L.A. ¾ pt. N.S.	3 L.A.	.....	.....	.....
9th cover	3 L.A.	3 L.A.	.....	.....	.....
10th cover	.....	3 L.A.	.....	.....	.....
11th cover	.....	3 L.A.	.....	.....	.....

	1944	1945	1946	1947	1948
Orchard 14					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A.	1 side	3 L.A.
2nd cover	3 L.A.	3 L.A.	3 L.A.	2 DDT 2 DDT only	3 L.A.
3rd cover	3 L.A.	3 L.A.	3 L.A.	2 DDT	3 L.A. 1½ DDT
4th cover	3 L.A.	3 L.A.	3 L.A.	2 DDT	2 DDT
5th cover	3 L.A.	3 L.A.	.....	2 DDT	1½ DDT
6th cover	.....	.....	.....	1½ DDT	2 DDT
7th cover	.....	.....	.....	2 DDT	.....
Orchard 15					
Petal fall	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
1st cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 L.A.
2nd cover	3 L.A.	3 L.A.	3 L.A. 1 side	3 L.A.	3 L.A.
3rd cover	3 L.A.	3 L.A.	3 L.A. 1 side	3 L.A. 1 side	3 L.A.
4th cover	3 L.A.	3 L.A.	3 L.A.	3 L.A.	3 DDT
5th cover	3 L.A.	3 L.A.	3 L.A.	.....	.....

1. The figure indicates pounds per 100 gallons of spray. L.A.=lead arsenate. DDT =50% dichloro-diphenyl-trichloroethane.
2. Different schedules were used in other blocks in this orchard in 1944 and 1945.
3. In 1946, one block in this orchard received a lead-arsenate, oil, and fixed nicotine schedule.
4. 25% DDT.
5. 50% DDT.

Records of spray gallons, per each year of the tree's age, used by growers are summarized in the following table. To obtain these figures the total three-years of the orchard, that is, the number of tree's times their average age in years, is divided into the number of gallons of spray used per each application.

Table 13. Average number of gallons of spray used per each year of tree's age.

Orchard 9

Year	Petal Fall	1	2	3	4	5	6	7	8	Ave.
1944	.43	.43	.44	.50	.53	.53	.53	.53	.53	.49
1945	.54	.53	.50	.50	.50	.50	.38	.38	.38	.47
1946	.60	.54	.57	.57	.54	.54	.51	.52	....	.55
1947	.53	.51	.48	.48	.47	.45	.41	....	....	.48
1948	.46	.46	.43	.43	.43	.38	.38	....	....	.42

Orchard 10

Cover sprays

Year	Petal Fall	1	2	3	4	5	6	7	8	9	10	Ave.
1944	.43	.31	.32	.33	.32	.34	.38	.37	....	....	....	.35
1945	.35	.33	.36	.38	.37	.37	.38	.32	.28	....	....	.35
1946	.43	.38	.36	.35	.36	.36	....	....	....	....	....	.37
1947	.37	.39	.38	.38	.39	.39	....	....	....	....	....	.38
1948	.37	.38	.36	.33	.34	.31	.33	....	....	....	....	.35
1949	.29	.29	.25	.30	.41	.37	.40	.40	.39	.39	.37	.35

Orchard 12

Cover spray

Year	Petal Fall	1	2	3	4	5	6	7	8	Ave.
1944	.54	.56	.46	.54	.58	.63	.61	.64	.58	.57
1945	.58	.20	.17	.17	.20	.16	.16	.14	.13	.21
1946	...	.43	.52	.34	.40	.52	.50	....	....	.45
1947	.68	.47	.71	.79	.93	.82	....	....	....	.73
1948	.76	.78	.74	.72	.72	....	....	....	....	.74

Orchard 13

Cover Sprays

Year	Petal Fall	1	2	3	4	5	6	7	8	9	10	11	Ave.
1944	.87	1.0	1.0	.87	1.2	.95	.99	1.1	.91	....	....	....	.88
1945	1.0	.72	.96	1.2	1.1	.....	1.2	.96	.96	.96	.72	.77	.96
1946	1.1	1.2	1.3	1.4	1.0	1.5	1.0	.....	....	....	....	....	1.20
1947	.73	.91	.82	.97	.91	.87	.....	.....	....	....	....	....	.87
1948	.75	1.00	.64	1.1	Dust	.86	.45	.....	....	....	....	....	.80
1944	1.00	1.22	1.23	1.87	1.45	1.56	1.99	1.78	.91	.96	.72	.77	1 20

Orchard 14

Cover sprays

Year	Petal Fall	1	2	3	4	5	6	7	Ave.
1944	.64	.67	.64	.63	.68	.69	....	....	.66
1945	.15	.12	.13	.12	.14	.12	....	....	.12
1946	.43	.43	.43	.43	.43	....	....	....	.43
1947	.45	.36	.37	.41	.50	.41	.27	.42	.40
1948	.48	.50	.46	.42	.48	.39	.48	....	.46

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